Illinois Research

Agricultural Experiment Station
Spring/Summer 1989

Marketing Illinois Products

College of Agriculture, University of Illinois at Urbana-Champaign, Volume 31, Numbers 1/2

THE COVER

Community farmers' markets are only one of several direct-marketing opportunities available to local growers.

"At a time unlike any in the past, we must envision the future."

Illinois Research

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W.R. "REG" GOMES

In March, W.R. "Reg" Gomes was named dean of the University of Illinois College of Agriculture following the departure of John R. Campbell, who assumed the presidency of Oklahoma State University. Dean Gomes brings to this position an exemplary record in both research and administration.

Gomes came to the University of Illinois in 1981 to head the Department of Dairy Science. Four years later, he became the head of the new Department of Animal Sciences. A distinguished scholar, he has coedited five books and authored or coauthored more than a hundred papers, articles, and book chapters.

During his tenure as a faculty member at The Ohio State University from 1965 to 1981, Gomes served in overseas posts twice: in 1974, as a Fulbright-Hays Distinguished Traveling Professor at Zagreb University in Yugoslavia and in 1980, as a visiting fellow and visiting professor at Kyoto University in Japan.

The grandson of Portugese immigrants, he earned his undergraduate degree in dairy science in 1960 at California Polytechnic State University, where he worked on the student dairy farm to meet college expenses. He specialized in animal physiology and endocrinology for both his Master's degree, received in 1962 from Washington State University, and his doctoral degree, received in 1965 from Purdue University.

As dean and as head of the Department of Animal Sciences, he has played a key role in developing several academic and building programs. For example, he was involved in the importation of Chinese swine and in obtaining funds for building the facility in which the pigs will be housed and studied.

Gomes strongly believes that the College of Agriculture has an essential mission to fulfill: "If we are to prosper in a changing world, it is vital that the importance of modern agriculture in the everyday lives of all citizens becomes part of the general educational process. It is up to the College to see that such education happens."

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Illinois Research

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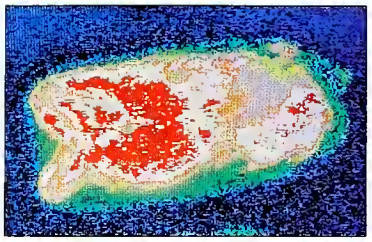
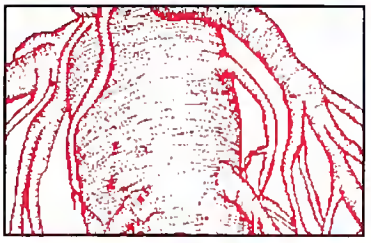
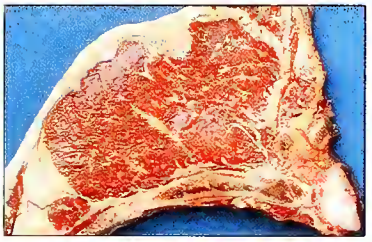
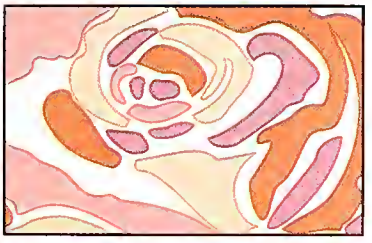








Marketing Illinois Agricultural Products

1989 – Directions – 1999

Serving Customers and Clients — the Key to Meeting Competition Effectively

Dr. Donald A. Holt, director, Illinois Agricultural Experiment Station

In his book, *Thriving on Chaos*, Tom Peters observes that successful private firms become "obsessed" with serving their customers and clients. According to this guru of business management, this degree of commitment is required to survive the stiff competition of the global marketplace.

Consumers of agricultural products are becoming more demanding. They are insisting on high-quality, safe, and affordable agricultural products. When they select among alternative products, they send important messages to producers, processors, and marketers of those products. This issue of *Illinois Research* reports how these groups can listen to, interpret, and respond to those messages.

Since science transformed agriculture a little over a century ago, agricultural production has increased to meet the growing demand for agricultural products. There is evidence, however, that agriculture is maturing as an industry.

In a mature industry, production capacity equals or exceeds the effective demand for products, and competition plays an important role in determining who will and who will not produce for the market. When supplies of products are ample, consumers can become much more discriminating in terms of quality and price. Under those conditions, the producers' emphasis must shift from finding markets for what is produced to producing what the market wants.

Marketing those products, moreover, is a complex activity, involving all components of a production and marketing system. Although advertising is important, it is only one part of marketing. Strategies to expand, penetrate, and capture markets may involve changes in research and development, production, processing, distribution, advertising and promotion, retailing, and modes of utilization. Successful strategies call for close coordination of technological changes in each of these important activities.

But in agriculture, the groups who produce, process, distribute, and market agricultural products are usually separated in space and time. Frequently, they are not within the same business structure. Communication among these groups is often difficult. One of the great marketing challenges is to improve communication and coordination within the entire agricultural infrastructure so that all agricultural groups can work together to respond more quickly and effectively to changes in demand for agricultural products. It is no longer possible for any of these groups to "go it alone."

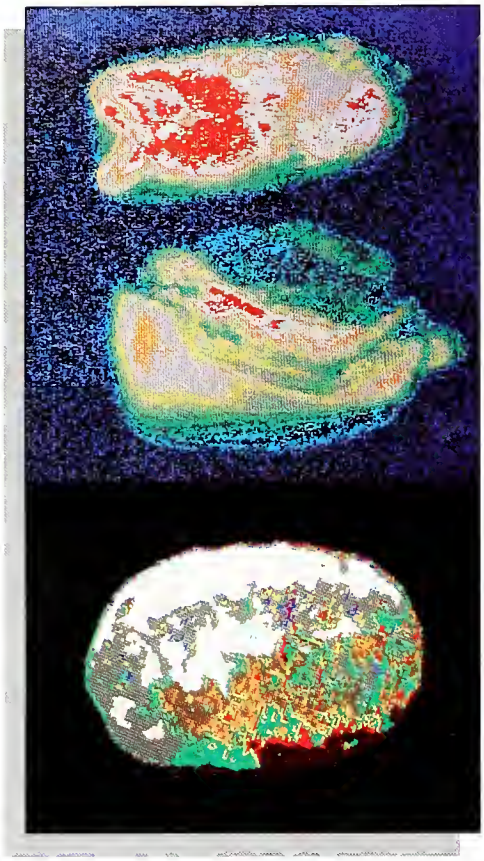
In the past, people have expressed concern that the competitive nature of a capitalistic system may result in the exploitation of consumers and workers. Certainly, however, there must be something basically good about a system in which people compete to see who can serve the consumer most effectively.

In modern capitalism, those who serve consumers most effectively are rewarded with higher incomes, greater continuity of employment, and, hopefully, the satisfaction of having done a job particularly well. For those who want to receive these rewards, the greater the competition, the greater the challenge to identify consumers' needs and desires precisely and to deliver affordable products, closely tailored to those needs and desires.

Donald A. Holt, director, Illinois Agricultural Experiment Station

Strategies for Marketing Agricultural Products

Lowell D. Hill



Computer images of corn kernels and a soybean showing mold damage.

Marketing has often been defined simply as selling and delivering products to processors or consumers, but this definition is inadequate in the highly competitive markets for most agricultural products. It focuses attention on satisfying the producers' need to move their products rather than on satisfying the needs and preferences of consumers.

Successful marketing requires identifying the buyers' needs and producing commodities designed to meet them. According to this view of marketing, producers must have their final consumers' needs in mind from the moment they plan production and select the variety to plant until they have delivered the final product. Successful marketing of agricultural products starts with genetic research and ends with postdelivery, service-oriented, follow-up communications with final consumers at home and abroad.

How can such a broad program be implemented? For most agricultural producers, this marketing strategy requires group action involving producer organizations, state and national government agencies, and university research to supplement the actions of individuals.

Corn kernels showing internal stress cracks created by rapid drying.

Identifying Consumer Preferences

In most instances, individual farmers are not in a position to survey the needs and preferences of final consumers. Farmers do occasionally have the opportunity to talk with domestic and foreign buyers about their preferences and problems related to an agricultural product. This information may influence future decisions. But for most agricultural products, farmers do not deal directly with final consumers and must market their raw products through local marketing or processing firms.

A systematic evaluation of consumer and processor preferences, therefore, requires the joint efforts of many farmers, who often utilize trade associations and community groups with contributed funds for market promotion. The various checkoff programs listed in the article by Richard A. Vogen in this issue are only one of many examples. University research, like the work on soybean characteristics desired by processors in the export market described in this issue by Karen Bender, can also provide information about domestic and foreign buyers' preferences. Farmers can use this information to guide their variety selections, handling methods, and market contracts.

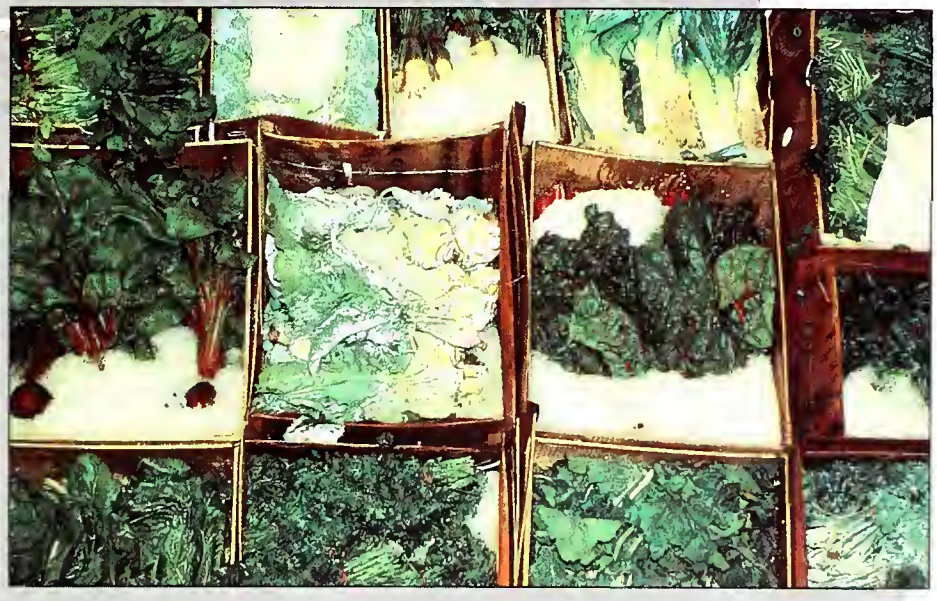
ACCOMMODATING BUYERS' PREFERENCES

Once the focus has been shifted from finding a market for what is produced to producing products the market desires, many opportunities emerge for improving the profitability of Illinois agriculture. Changes in the variety of corn and soybeans selected can alter physical and chemical properties to meet the needs of processors. Steven R. Eckhoff, Marvin R. Paulsen, and J. Bruce Litchfield note in their article, for instance, that hard endosperm varieties of corn are more profitable for dry millers. Color, size, and packaging are important to consumers of fresh fruits and vegetables.

Price stability and reduced risk of price changes are important to many foreign buyers of grain and livestock products. U.S. producers and marketing firms shift some of these risks to other people by using organized futures markets. The functions and importance of commodity futures and options markets are discussed in greater detail in this issue by Philip Garcia, Raymond M. Leuthold, and Robert J. Hauser.

The opportunity to shift risk does not exist in many countries and is not available for all U.S. commodities, such as those sold in the thin markets described by Sarahelen R. Thompson in her article. Financial risks sellers and buyers absorb can add to the cost of marketing.

Strategies for marketing should consider this additional cost, precede production, and include the identification of



After early morning deliveries have been made, retailers' trucks line up to pick up fresh produce daily at the South Water Market in Chicago (top).

This broker on the phone at the South Water Market is purchasing produce for quality-conscious consumers (middle).

Leafy green vegetables from Plainfield, Illinois, on display at the South Water Market (bottom).

domestic and export specialized markets. Contracts with buyers are becoming more common even in commodities, such as corn and soybeans. They assure the producers of a market and identify the product characteristics that will bring the highest price.

As Barbara P. Klein points out in her article on trends for marketing fresh meat, buyers' tastes and preferences are subject to change. Noreen Frye describes the dramatic impact on sales and consumer attitudes of several very successful advertising campaigns of the pork industry.

Promotion and advertising may alter preferences, but they also provide buyers with more information for making choices among alternative products and qualities. Producers, as Michael A. Hudson reports in this issue, should and do take an active role in product promotion, but they also need to choose advertising strategies that pay more than they cost.

The relationships between raw product characteristics and the quantity and quality of processed products are not always known. This information is essential if processors are to make the best choice of quality for their purposes.

Researchers at the University of Illinois are studying food processing to provide this information to domestic and foreign buyers. For example, specialists investigating the manufacture of starch and sugar from corn have identified that reducing the amount of heat used in drying high-moisture corn will increase the yield of starch. Other researchers have examined the chemical composition of soybean oil and the soybean's genetic potential for being chemically altered to meet specifications for certain specialized industrial uses.

Finding a Market Niche

With the emphasis on the customer's preferences, important differences soon become obvious. Cultural differences in food preferences are generally recognized but not always given consideration, especially in the export market.

U.S. exporting firms often fail to recognize that what U.S. consumers find appealing in a product's form, consistency, and color may not sell well in the Orient. Japan has recently purchased a beef feedlot in the United States because importers were looking for a more highly marbled beef than they were receiving from U.S. exporters.

Similarly, the preference of Italian poultry feeders for dark yellow skins on broilers induced premiums for Argentina corn for many years.

More significant differences in preferences are those related to the processing industries. The "best" chemical and physical characteristics of corn and soybeans depend on the industry. Hard endosperm corn is desirable for dry milling firms producing corn flakes, but it will increase the processing costs in wet milling, where starch and corn sweeteners are extracted through a steeping process. Processors in Denmark are requesting high protein soybeans for the manufacture of protein extenders; oil crushers in Japan are asking for higher oil in soybeans even if it means lower protein content. Korean tofu producers want large beans; Japanese producers of bean sprouts want small ones. For processors, all corn and all soybeans are not alike.

Even for traditional crops like corn and soybeans, effective marketing requires that producers identify the market niche where they can best supply products with the desired characteristics to domestic and foreign consumers. J.W. Courter and David J. Williams discuss this and other essential considerations for marketing horticultural products.

Many small-volume markets are seeking reliable suppliers of agricultural products with unique characteristics. Opportunities often exist for increasing sales through further processing or otherwise altering the product, as Gene E. Campbell and Gary L. Rolfe demonstrate in their article on opportunities for marketing forest products. Alternative market outlets, such as the pick-your-own ventures described by J.W. Courter, present additional opportunities.

Marketing and production decisions must be integrated into a unified strategy in order to direct needed resources and management skills into these markets. By responding quickly to new market opportunities, smaller companies can effectively compete with multinational corporations even in export markets.

Lowell D. Hill, professor of agricultural marketing, Department of Agricultural Economics

Soybean Quality Characteristics: What's in a Grade?

Karen L. Bender

U.S. standards for soybeans, first issued as tentative grades in 1924 and brought under the United States Grain Standards Act in 1940, emphasized the physical properties considered important in marketing soybeans. These grades have changed relatively little since they were published in 1924.

Researchers at the University of Illinois College of Agriculture are investigating the need to change the quality characteristics that should be measured in grades and standards to provide the information desired by processors in the export market. Because soybean grades should provide information about value to soybean processors, it is important that these grades reflect their preferences.

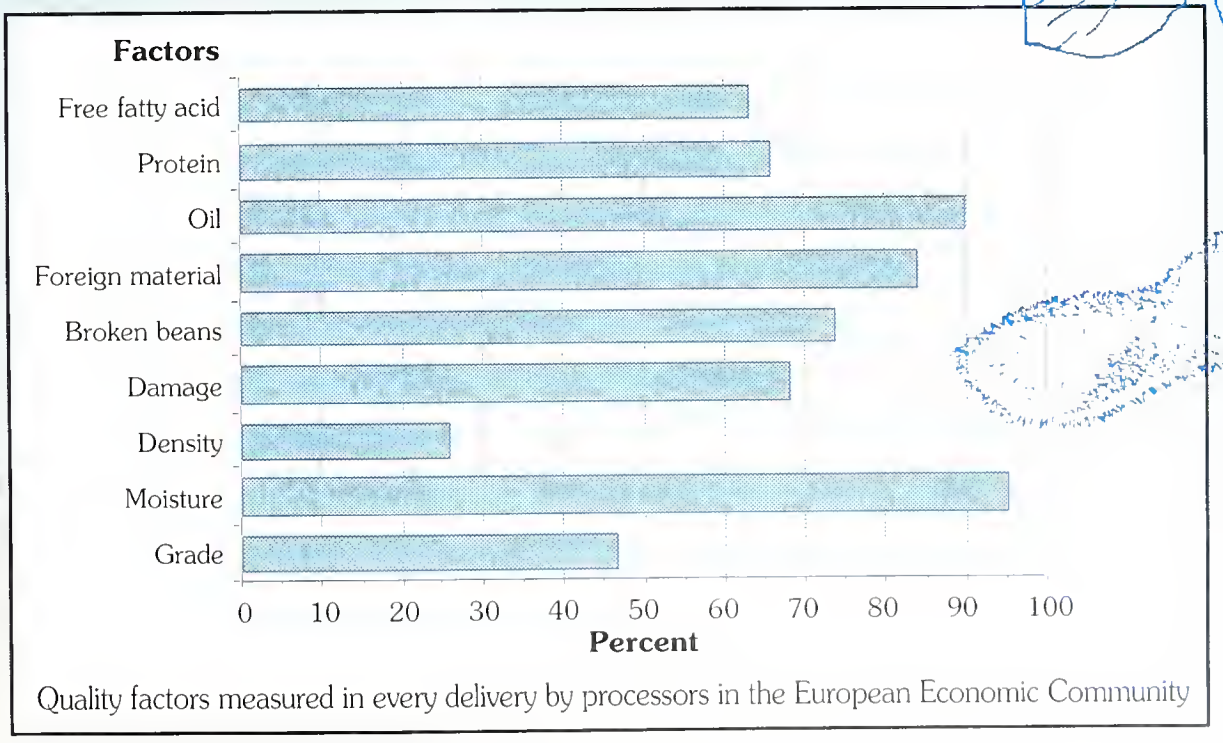
A study conducted jointly by the University of Illinois Department of Agricultural Economics and the Institut de Gestion Internationale Agro-Alimentaire, based in France, used a mail survey and personal interviews to determine which soybean product characteristics were sufficiently important to processors in Western Europe that they were measured on every shipment when received at the plant. It was assumed that measurement would only take place if the information gained was more valuable than the actual cost of measurement. In all, 25 surveys were obtained. Of these, 23 were determined to have enough detailed information to be usable in calculations. Over 80 percent of these processors measured moisture, oil, and foreign materials in every delivery as shown in the accompanying figure.

In a second study covering a broader range of countries, processors were asked to rank the importance of quality characteristics on a scale of 1 to 7. This study was conducted in cooperation with the American Soybean Association and the Office of Technology Assessment. Of the 34 usable surveys, the average rankings on protein, moisture, and oil were 6.8; on free fatty acid, 6.6; and on foreign material, 6.5. Only two of the soybean characteristics that were ranked above 6.5 — moisture and foreign material — are included in U.S. grades. Other grade factors — test weights and splits — were ranked 5.0 and 6.0, respectively.

Identifying important quality characteristics provides a basis for organizing a marketing system to deliver what the buyers want. The United States has achieved some success in providing characteristics found desirable in both studies. In comparison, Brazil and Argentina frequently furnish oil and protein content data but rarely give grade information because it is not generally requested.

A continuing challenge to researchers, therefore, is identifying processors' quality preferences because these preferences provide a basis for changing U.S. grades to include economically important characteristics. Reporting this information on export certificates and using it in the market channel will increase market efficiency.

Karen L. Bender, visiting research specialist in agriculture, Department of Agricultural Economics



Quality factors measured in every delivery by processors in the European Economic Community

Processing the Right Corn

Steven R. Eckhoff,
Marvin R. Paulsen,
and J. Bruce Litchfield

Korean wet and dry corn milling facility.

About 1.5 billion bushels of corn a year are processed into food or industrial products by wet or dry milling. Wet corn milling produces such products as starch, high fructose corn syrup, corn oil, and ethanol. Dry corn milling yields corn oil, corn flour, corn meal, and corn grits for use in flaking into breakfast cereals, brewing into alcoholic beverages, and extrusion into corn-based snacks.

Achieving efficient mill operation and an optimal yield of products requires processing corn with the right characteristics. Current grade factors, however, do not reflect the different quality characteristics that are needed in corn milling.

Variety is important in dry milling

Hard endosperm varieties have been found to yield more large grits per bushel and more profit for the miller. Recent studies in Japan and Korea funded by the U.S. Feed Grains Council have demonstrated to millers in those countries that purchasing these varieties of corn can increase profits by $0.20 to $1.00 per bushel.

A major problem in supplying international millers with this quality of corn is that the U.S. grain merchandising system has no low-cost method of keeping such corn segregated. U.S. millers overcome this problem by paying a premium for corn either directly to farmers or through selective purchasing.

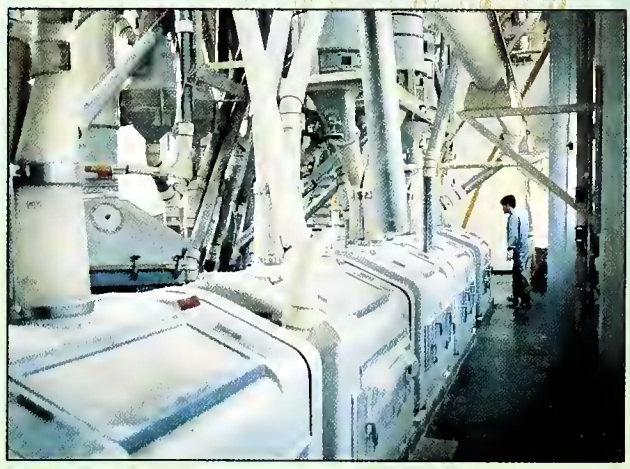
Drying conditions affect yields

Another important factor in corn quality for milling is the conditions used in drying corn. Conventional high-temperature drying, above 140°F (60°C), causes the development of stress cracks in corn, which greatly reduces the grit yield in dry milling. In wet milling, chemical and physical changes in the corn during high-temperature drying can cause a 5 to 10 percent decrease in starch yield. Currently, no accepted laboratory method is available to determine rapidly whether a corn lot has been high-temperature dried.

Researchers at the University of Illinois are trying to increase domestic and international corn utilization by improving the profitability of corn milling. Their work involves developing new products and new processes as well as determining the most important characteristics of corn needed for the two milling systems. The increased utilization of corn due to new products and more economical processes will ultimately result in more profit for Illinois farmers.

All corn is not created equal. The most appropriate corn characteristics, such as hard or soft endosperm, and the drying procedure used must be identified so that the right corn can be used in each milling process.

Steven R. Eckhoff, associate professor; Marvin R. Paulsen, professor; and J. Bruce Litchfield, assistant professor, Department of Agricultural Engineering



Dry corn milling roll stands in Korean mill.

Developing Markets for Illinois Agricultural Products

Richard A. Vogen

As long as food has been produced for organized society, a demand for agricultural products has existed. Occasionally, the demand is obvious as in the case of Jacob, who having heard that there was grain in Egypt, sent his sons there to buy some. Pharaoh did not have to market very aggressively to meet this obvious demand of Jacob and his starving sons. More often, however, competition is fierce, and demand must be developed through marketing.

Market development is a discipline used in many industries to enhance the existing demand for a product; it is especially useful for products with relatively uniform characteristics, such as agricultural commodities.

Closely related to this discipline is stimulation marketing, which creates a demand where none previously existed. In recent years, for example, demand was created for corn sweeteners and ethanol; and important markets were stimulated for these products.

Giving Buyers What They Want

Effective marketing relies on discovering the needs, wants, and preferences of actual and potential buyers of a product to serve as bases for decisions involving its design, production, pricing, method of communication with its market, and distribution. Successful marketing management, therefore, requires thorough analysis, planning, implementation, and control of marketing programs.

How Agricultural Markets Differ

The same principles of marketing hold true for agricultural products, but Illinois farmers, as producers of essentially raw materials, may face different marketing problems than those seen by many other people in business.

Lack of control. With the exception of direct marketing of some perishable and specialty products, agricultural producers seldom control marketing beyond the farm gate.

Same basic well-known products. Agriculturists are in a somewhat unusual position because many have the same basic products, and these products or their substitutes are reasonably well known to their markets. But for a number of reasons, the full potential of these markets may remain undeveloped: inefficient product utilization, lack of purchasing power, and logistical impediments. To develop these markets, individual producers need to pool their resources or find public resources.

Expanding Markets at Home

Market development is often thought of only in relation to exports. Foreign markets do offer excellent potential for further development, but domestic markets for food and agriculture can also benefit from market development. Major commodity organizations have influenced the demand for their commodities through a variety of programs: advertising, product education, product development, and various promotional activities.

The markets for Illinois's most abundant commodities — corn, soybeans, pork, beef, and dairy products — for instance, have effective market development programs. Lamb and wool, apples, peaches, nursery products, wood products, vegetable crops, and even honey, horseradish, and other products also derive benefit from market development and could potentially be expanded.

Checkoff Programs

Producer programs that check off funds at the first point of sale, such as the Illinois Corn Marketing Program, the Illinois Soybean Operating Program, the Illinois Apple and Peach Marketing Program, the Illinois Sheep and Wool Marketing Program, as well as national checkoff programs for pork, beef, and dairy, can accumulate resources for very effective market development. These programs conduct market analysis and research aimed at the development of new products or better marketing systems for commodities. Either can yield dividends when consumers' needs and wants are satisfied. These programs also seek to encourage new uses of traditional products.

State Efforts Promote Products

Statewide promotional efforts can be directed toward developing consumer loyalty for locally produced, high-quality products. The campaign by the Illinois Department of Agriculture (IDOA), which uses the Illinois Product Logo to promote state products is just one example.

Research indicates that Illinois consumers would like to purchase more Illinois products but often have found it difficult to identify a product's origin. Intended for use in the merchandising and advertising programs of individual Illinois growers, processors, and food manufacturers, the Illinois Product Logo shown here eliminates this problem by identifying this state's products. Illinois companies may also include it on package labeling. To apply for authorization to use the new logo, write or call the Illinois Department of Agriculture, Division of Marketing, State Fairgrounds, P.O. Box 19281, Springfield, Illinois 62794-9281; (217)782-6675.

Market development for Illinois processors and manufacturers of food products will increase not only opportunities for employment in those industries but also the demand for the raw materials used in manufacturing and processing. For many sectors of agriculture, strategically located processing facilities are essential to the development of a market for producers. The Illinois Farm Development Authority is instrumental in providing capital for such ventures.

An important aspect of market development is the fostering of relationships between buyers and sellers through business referrals and formal commercial activities, such as trade shows. Illinois's trade referral service and Illinois Food Expo shows, administered by IDOA, serve some of these needs. Small companies can benefit in particular from these services. For example, Eli's, a small but rapidly growing Chicago-based cheesecake company, has effectively used state programs to increase distribution into national food service and retail markets.

Developing Markets Abroad

The United States has organized a sophisticated network for international market development of agricultural products, mainly overseen by the Foreign Agricultural Service of the U.S. Department of Agriculture (USDA). A group of cooperators from the government and industry, including the American Soybean Association, U.S. Feed Grains Council, and Mid-America International Agri-Trade Council, has combined public and private resources to carry out worldwide programs of market development for an impressive array of U.S. food and agricultural products.

The USDA's "Targeted Export Assistance," export credit guarantees, export bonus programs, and "Food for Peace" programs have also been effective tools for trade, enhancing demand for U.S. agricultural commodities in many markets where the extra incentive is necessary to compensate for limited purchasing power and to overcome unfair trade practices by foreign governments.

Other organizations and institutions play significant supporting roles in market development for Illinois agricultural products, including the state's agricultural colleges and experiment stations, as well as the Illinois Farm Bureau, the commodity exchanges, local and municipal economic development agencies, and various support businesses, such as financial institutions and transportation companies.

Illinois is poised not only to reap the benefits of the commodity trade, but also the benefits of many of the diversified international opportunities in foods, specialty products, and agribusiness products and technology. Illinois's consistently high farm production, coupled with excellent waterway and rail transportation to major ports, has given us an advantage in the export of corn and soybeans.

Moreover, we in Illinois can add value to our products through manufacturing, and we can develop additional markets overseas. Some countries, like Japan, are becoming large markets for processed foods, such as variety meats, and for packaged meals, fruits, and vegetables. Other markets, like China, present opportunities in grain storage equipment, agricultural chemicals, and breeding animals.

In concert with the export trade and reverse investment activities of the Illinois Department of Commerce and Community Affairs, with export financing by the Illinois Export Development Authority, and with special export projects of the Illinois Export Council, IDOA assumes responsibility for international food and agricultural market development on the state level. Providing information, consulting, and marketing promotions are the primary functions of IDOA's Bureau of International Marketing, which finds Illinois products for foreign inquirers and business leads for Illinois companies.

More Competitive Marketing

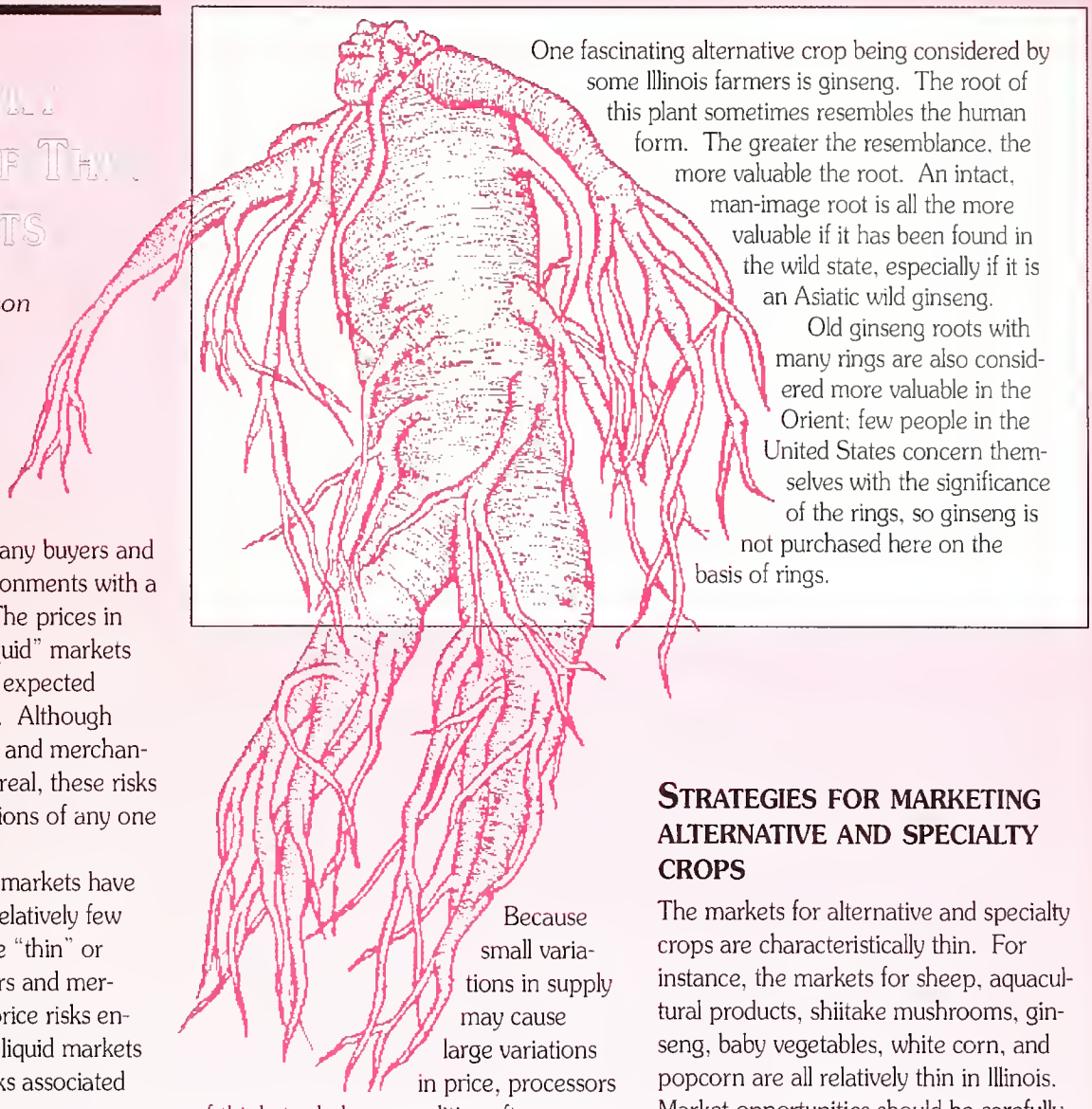
U.S. market development has become so sophisticated that competitors have adopted excellent programs of their own. The future of agricultural marketing promises to be increasingly competitive, so the scope of market development will necessarily expand and change.

A market, however, is never fully developed. One market opportunity leads to another. Creative energy drives this process of innovation and growth.

Richard A. Vogen, former superintendent, Division of Marketing, Illinois Department of Agriculture, and regional director — Eastern Europe and the Soviet Union, U.S. Feed Grains Council

The Risky Business of Thin Markets

Sarahelen R. Thompson



One fascinating alternative crop being considered by some Illinois farmers is ginseng. The root of this plant sometimes resembles the human form. The greater the resemblance, the more valuable the root. An intact, man-image root is all the more valuable if it has been found in the wild state, especially if it is an Asiatic wild ginseng.

Old ginseng roots with many rings are also considered more valuable in the Orient; few people in the United States concern themselves with the significance of the rings, so ginseng is not purchased here on the basis of rings.

In a number of important agricultural markets, such as the markets for corn and soybeans in Illinois, many buyers and sellers do business in environments with a large volume of trading. The prices in these easily accessible, "liquid" markets closely approximate those expected under perfect competition. Although price risks to the producer and merchandiser in these markets are real, these risks are not affected by the actions of any one individual in the market.

Many other agricultural markets have low volumes of trade and relatively few buyers and sellers. In these "thin" or "illiquid" markets, producers and merchandisers face the same price risks encountered when trading in liquid markets as well as the costs and risks associated with trading in thin ones.

Why is thin-market trading more risky and expensive?

The first explanation is that market information may be scarce and marketing opportunities difficult to recognize. Obtaining information and discovering market opportunities may entail direct expenditures by the producer or merchandiser.

Another reason for the additional risks and costs is that prices in a thin market may be strongly influenced by the actions or marketings of individual traders. Prices, therefore, are affected by the quantity marketed, and the trading environment is conducive to the exercise of monopolistic power. Monopolies exist where one firm or a few firms acting together pay sellers a lower price than would be paid under competitive conditions.

Because small variations in supply may cause large variations in price, processors of thinly traded commodities often contract with producers for processing supplies. Although contracting may provide information to producers about expected price, it may also limit their marketing opportunities if few buyers other than contracting processors are available — a third reason for the additional risks and costs inherent in thin-market trading.

Finally, merchandisers in these markets may require large gross margins to justify trading in a risky environment with low volumes of trade. A gross margin is the difference between the price the merchandiser pays to suppliers and the price received by merchandisers from buyers. Large gross margins imply lower prices to producers than those received in more liquid markets. These lower prices are yet another source for the additional costs and risks found in trading in thin markets.

Strategies for marketing alternative and specialty crops

The markets for alternative and specialty crops are characteristically thin. For instance, the markets for sheep, aquacultural products, shiitake mushrooms, ginseng, baby vegetables, white corn, and popcorn are all relatively thin in Illinois. Market opportunities should be carefully researched by prospective producers to determine the profit potential of these animals and crops. Buyers must be identified in advance, and forward contracting should be investigated.

For many of these markets, producers could find themselves with far lower returns than expected if they do not thoroughly analyze the effect on price of a small increase in supply. For some producers, however, these crops may offer attractive returns if markets, once discovered, are accessible, and if prices either can be set by a forward contract or predicted with a high degree of confidence.

Sarahelen R. Thompson, assistant professor of agricultural marketing, Department of Agricultural Economics

Promoting Agricultural Commodities

Michael A. Hudson

In recent years, campaigns to promote or further the growth of agricultural commodity consumption have significantly increased. Promotion programs for cattle, hogs, corn, soybeans, and numerous specialty crops have been created with checkoff funds from commodity producers. Specific products targeted to niche markets have been promoted by groups of producers who have banded together for this purpose.

Although such interest in promotion is by no means unique to agricultural products, the expanded emphasis in recent years raises a number of questions: Why has the sudden explosion of advertising and promotion programs for agricultural products occurred? Who should bear the cost of advertising and promotion programs? Who really benefits? Should the programs be generic or product oriented?

To answer these questions, we need a perspective on the promotion of agricultural products that includes the rationale behind promotion programs, a brief examination of their history, and discussion of some ongoing related issues.

Why do we need to promote agricultural products?

When selling a product, any number of factors are important, including its form and the time and places it is available. The task of advertising and other forms of promotion is to communicate these factors to current and potential consumers.

Aims. Besides informing, promotion is used to persuade, to remind, and to reinforce. The highly successful Nutri-Facts campaign conducted by the National Live Stock and Meat Board in the mid-1980s illustrates each of these activities: it *informed* the public about the nutritional attributes of meat and meat products; it *persuaded* consumers to continue their use in spite of the negative press related to the potential health risks; it implicitly *reminded* those already consuming the product about its benefits; and it *reinforced* the satisfaction of those consuming it both before and after purchase. Effective promotion, therefore, creates or heightens consumer awareness — particularly about desirable product attributes.

Stages in the life of a product. Figure 1 depicts the five stages in the life cycle of a product in terms of the levels of its consumption. During the *developmental* stage, promoters often try to make consumers aware and solicit their input about the form of the product. Once developed, the product is *introduced* in the marketplace, where its level of consumption increases slowly as awareness gradually increases. Then with increasing availability, the product moves into the *growth* phase, in which more

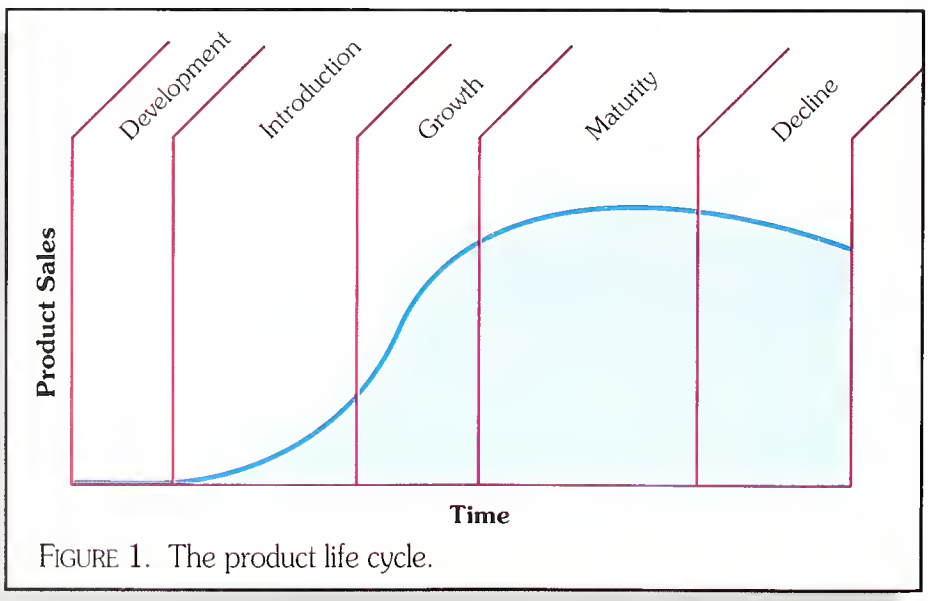


FIGURE 1. The product life cycle.

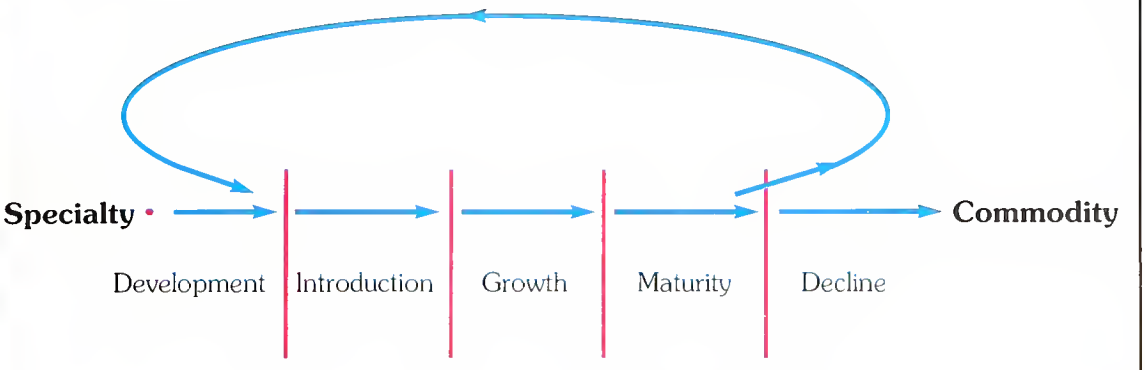
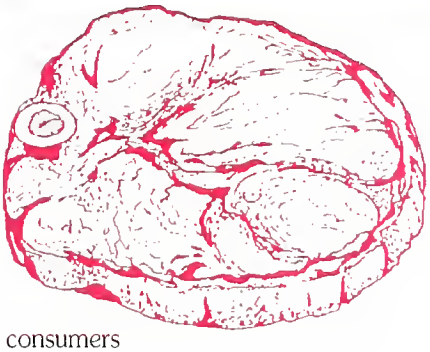
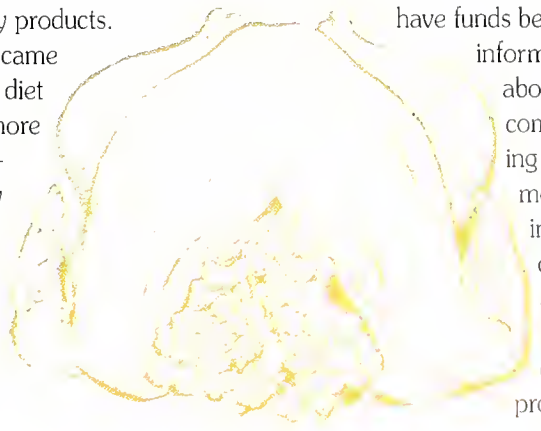


FIGURE 2. The bent-arrow effect of innovation on a product's life cycle.



consumers begin to purchase it. At some point, however, the market begins to become saturated, and the rate of growth levels off. This *mature* stage is followed by a *decline* in consumption, which is often associated with substitute products entering the marketplace.

An example of the product life cycle can be seen in the beef industry over the past four decades. In the 1950s, following World War II, beef entered the growth phase as consumers developed a taste for grain-fed beef and the product was introduced on a wide scale. During the 1960s and early 1970s, growth continued. But in the late 1970s, the market matured, and substitutes entered — such as processed poultry products. As consumers became concerned about diet and health and more interested in convenience, poultry products were substituted for beef products, moving the product into the stage of decline.



Innovation — the key to new growth. Markets for products mature, and eventually their consumption declines unless some innovation is made to launch the product into a new life cycle. A product may be a specialty product when introduced, but it becomes a commodity as it moves through its life cycle. The key to stimulating new growth is to bend backward the arrow in Figure 2 depicting the product's growth and make the commodity a specialty item again — thereby beginning a new life cycle. Familiar examples of innovations in products and the promotions associated with them are the microwavable hamburger and precooked vacuum-packaged beef roast.

HISTORICALLY, GENERIC APPROACH TAKEN

Although the maturity of markets for agricultural products is a relatively recent phenomenon, the promotion of agricultural products has a long and rich history. Much of it records attempts by commodity groups to increase the demand for a generic commodity. Only recently have funds been focused more on informing consumers about the benefits of commodities, developing new forms of commodities, and promoting specific brands of commodities, such as Angus beef.

Legislated producer promotion programs were first initiated in the mid-1930s when the Florida legislature passed a number of citrus regulations aimed at helping the depressed Florida citrus industry. By 1940, five states had passed similar checkoff programs: Idaho adopted one for vegetables; Washington and Michigan, one for apples; Maine, one for potatoes; and Iowa, one for milk. The number and scale of such programs have grown greatly since 1940: 312 legislated programs covering 80 different farm commodities are currently in effect.

One of the most important changes in recent years was the consolidation of state promotional programs for dairy, beef, and pork. These programs were nationalized to facilitate better coordination across states and to ensure equity of contributions from all commodity producers. To gain political support, local and regional groups have been assured a significant share of promotion and research efforts.

ISSUES INFLUENCE FUTURE OF PROMOTION CAMPAIGNS

The success of commodity promotion programs is largely dependent upon the level of participation in them, the nature and scope of the promotions, and their impacts on consumers. Although there is no doubt that these programs have been important for numerous commodities, there is by no means unanimity of agreement about the need for them.

Tapping to Demand with Effective Advertising

Noreen N. Frye

Consumers choose among a variety of products every time they make a purchase, and many of those choices are influenced by advertising and promotion. The message carried by advertising is intended to create awareness of a product. But a creative, well-thought-out advertising campaign can do much more; it can create an image for a product and even change one a product already has.

The pork industry's advertising campaign is an example of how advertising can have a dramatic impact on sales and consumer attitudes. The National Pork Producers Council has a history of creative advertising, building campaigns around such catchy messages as "America, you're leaning on Pork" and "Pork, What A Good Idea." In the early 1980s, however, pork was losing out to other kinds of meat at the meat counter.

The Council hired an agency to research consumer attitudes toward pork and develop a communication and marketing program to attract consumers to it. The agency found that many consumers avoided pork because they thought consuming it was less healthy than consuming other meats.

To counter that image, the agency created the message: "Pork, The Other White Meat." They developed advertisements showing pork prepared in versatile, new, healthy ways.

The new message and campaign in test markets changed consumer attitudes about pork in a matter of months. As the other white meat, pork became light, lean, and nutritious — the qualities consumers associate with fish and chicken. Attractive, tempting pork dishes advertised on television showed the versatility of pork and stimulated sales at meat counters.

Rozmarin and Associates, an independent research firm in Omaha, Nebraska, measured consumer reactions to the new campaign against a study conducted before the campaign got under way. It reported that consumer association of pork as a white meat increased 163 percent after only 6 months' exposure to the new campaign. In some test markets, consumer recall of the primary message of the campaign was as high as 72 percent.

Effective advertising depends not only on finding the right message and developing a campaign, but also on sustaining the effort. The pork industry attracted consumers with a message in 1987 and 1988. Now, it intends to reinforce that message through television and radio advertisements in major metropolitan areas where pork is not selling well and in national consumer magazines.

State organizations, under the guidance of promotion committees, will target major cities for advertising. Chicago and Rockford are target cities in Illinois. The Illinois campaign is diverse, including television advertising tied to sport and other consumer special events, radio and newspaper advertisements, billboards, and retail promotions.

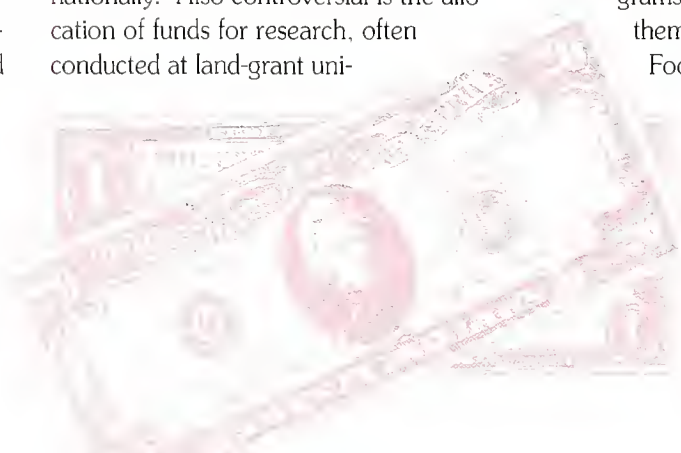
The market for pork has increased since the new campaign started. That increase means the demand was always there. Advertising was a tool for tapping into that demand.

Noreen N. Frye, director of product marketing, Illinois Pork Producers, Springfield, Illinois

Several issues coloring the debate in recent years are likely to continue having an impact on the promotion of Illinois's agricultural commodities and products.

Support base. Of the four primary approaches to funding promotion programs — public, producer, voluntary, and mandatory funding, the voluntary approach has been the historical backbone of these programs. In recent years, however, voluntary funding has been replaced by a legislated mandatory approach. Despite the mandatory nature of these programs, some producers debate their true benefits, sometimes resulting in an unwillingness to provide support. This unresolved issue may ultimately lead to some restructuring of promotion programs and distribution of funds.

Geography and money. The geographic dispersion of commodity producers, coupled with the mandatory "checkoff" nature of many promotion programs, raises a number of questions related to the dispersion of funds. Of particular concern is whether commodities should be promoted regionally or nationally. Also controversial is the allocation of funds for research, often conducted at land-grant universities. The potential benefits of allocated funds and where the research will be conducted generate much discussion. Maintaining an equitable balance in the resolution of this complicated issue may require much effort.



Generic versus product focus. Many promotions funded by these programs are targeted toward generic themes, like "Beef Is Good Food" and "Pork, The Other White Meat." Some experts would argue that product promotions are more effective, such as the "America's Cut" campaign.

At the heart of the debate about commodity

The National Pork Producers Council adopted this official porkmark and slogan to speak with a unified and clear voice to its various publics.

The Other White Meat.®

promotion programs is the question of who benefits. Generic advertising appears to benefit more producers, but when ineffective, it threatens the survival of commodity programs. In terms of benefits received, product-specific promotions may be more effective but are likely to exclude some of the producers who are footing the bill.

Evaluating the impact of promotion campaigns. The impacts of generic and product-specific promotion programs are difficult to assess. The academic research community has an important role to play here in developing appropriate models for measuring the returns to these expenditures.

This task is extremely difficult, however, in mature markets, where some expenditures may be simply staving off further declines and not resulting in significant increases in consumption. Analysts need to consider the success of promotions based on their ability to inform, persuade, remind, and reinforce. Measuring only their ability to persuade, shown by increased purchases, is misleading and will likely understate their true success.

Program longevity. Although a number of promotion programs have existed for many years, the future of these programs is uncertain. The case could be made that such programs are needed only for a short period of time — when markets mature — and that they are not needed in the long run. However, as long as the production of agricultural commodities remains in the hands of geographically dispersed and independent producers, such programs are likely to be needed for maintaining and expanding markets.

Promotion programs for agricultural commodities have a long history. Although viewpoints vary about their success and impact, these programs provide an important means of creating consumer awareness, which would otherwise not exist for many commodities. The structure and impact of such programs are likely to be a source of continuing debate and will no doubt be significantly influenced by the success or failure of current programs. Producers and economists have important roles in these discussions: ensuring equity of programs and measuring their impacts.

Promotion programs will quite likely continue expanding in the next decade although their full scope will depend on the evolution of the food and agribusiness sector. The tremendous potential for producers and groups of producers to develop specific market niches suggests that these programs will continue to play an important role. No doubt, in the near future some innovative moves will be made in the design and delivery of promotions and the evaluation of their impacts.

Michael A. Hudson, associate professor of agribusiness management and marketing, Department of Agricultural Economics

For more information about the promotion of agricultural commodities and products, write or call the following organizations:

- National Live Stock and Meat Board
  444 North Michigan Avenue
  Chicago, Illinois 60611
  (312)467-5520;
- National Cattlemen's Association
  5420 South Quebec Street
  P.O. Box 3469
  Englewood, Colorado 80155
  (303)694-0305;
- National Pork Producers Association
  P.O. Box 10383
  Des Moines, Iowa 50306
  (515)223-2600;
- National Corn Growers Association
  1000 Executive Parkway
  Suite 105
  St. Louis, Missouri 63141
  (314)275-9915;

or

- American Soybean Association
  P.O. Box 27300
  777 Craig Road
  St. Louis, Missouri 63141
  (314)432-1600.

Also available is a helpful series of six pamphlets: *Generic Agricultural Commodity Advertising and Promotion*, prepared by the Northeast Regional Committee on Commodity Promotion Programs (A.E. Ext. 88-3).

A complimentary set of pamphlets can be obtained by writing or calling:

Doris Shoemaker
Department of Agricultural Economics
52 Warren Hall
Cornell University
Ithaca, New York 14853
(607)255-2102.

Trends for Marketing Fresh Meat Respond to Consumer Concerns

Barbara P. Klein

Consumers' perceptions about the role of meat and meat products in their diet are changing, and so are the ways these foods are marketed.

Concerns reflect health recommendations and social and economic trends

Noting consumers' traditional liking for meat and meat products, surveys point to consumers' health and weight concerns, desire for "fresh" and "natural" foods, and awareness of animal production and processing practices. Recommendations from health agencies to limit cholesterol and fat intake from animal products, to reduce salt intake, and to avoid weight gain, have resulted in an unprecedented concern about the nutrient content of food, specifically with respect to meat.

Strategies for marketing fresh meat have taken advantage of the health consciousness of the consumer by providing nutrition information at the point of sale and by promoting leaner cuts of meat and low-fat recipes. "Light" or "low-fat" meat products can be prepared with greater control of the amount and type of fat to help consumers achieve their health and nutritional goals.

Leaner cuts. The leanness of retail cuts of beef and pork has improved considerably in the past 20 years. The optimum fat content of beef recommended for consumer acceptability ranges between 3 and 7.3 percent, corresponding to U.S. Department of Agriculture (USDA) grades from "Good" to "Choice," according to the 1986 National Consumer Retail Beef Study.

Marketing meat on the basis of USDA grades, however, is not an effective strategy because consumers are confused about the meaning of these grades. Surveys show that consumers look for lean meat but erroneously associate the "Prime" grade, which is highest in fat, with leanness.

Studies conducted at the University of Illinois on consumers' perceptions of meat quality suggest that tenderness, juiciness, and other characteristics that they thought important may be inconsistent with very lean meat. This contradiction must be considered in developing and promoting beef and pork that are lower in fat.

Closer trimming. Another approach to decreasing the fat content of cooked meats is marketing more closely trimmed meat. Overall fat thickness on all cuts of meat available in retail stores is less than 1/8 inch according to surveys conducted by the USDA and beef industry organizations. This amount of fat represents a gradual decrease from the industry standard of 1/2 inch since the early 1980s.

Research in the Department of Animal Sciences and the Division of Foods and Nutrition suggests that the cooked lean portion of meat has the same amount of fat whether it is trimmed before or after cooking, although trimming the fat from meat before cooking reduces the total amount of fat available for consumption. In fact, the small amount of fat trim indicates that the meat available in retail outlets is considerably lower in fat than USDA food-composition data suggest. Elimination of visible fat trim, then, is an important marketing strategy.

Lean (Good or Select) meat (above) and highly marbled (Prime) meat (below)

Easier preparation. In addition to nutritional concerns, social and economic trends indicate that consumers are looking for ready-to-eat and quick-to-prepare meat products. Developing new products, particularly precooked meats, may offer the greatest opportunity for meeting consumer demands. Positioning prepared fresh meat products either with refrigerated foods or in an in-store delicatessen brings these products to the attention of the time-conscious consumer. Studies are under way at the University of Illinois to confirm the safety and eating quality of precooked beef and pork.

Retaining foodservice markets

Foodservice establishments, ranging from the fast-food outlet to the "white tablecloth" restaurant, are judged by the quality of their meat products. Restaurant offerings are more diverse and cater to the "new" consumer who has larger amounts of disposable income and is more adventurous in food selection. Fresh meats other than beef and pork — such as lamb, veal, and game — are gaining new audiences. But beef and pork producers have countered by providing innovative foodservice-oriented recipes that capture the imagination of affluent restaurant clients.

Marketing strategies for fresh meats, therefore, must include providing information about food preparation to both home food preparers and foodservice operators as well as educating consumers about meat's unique contributions to the diet and supplying high-quality processed and fresh meats that are lower in fat.

Barbara P. Klein, professor of foods and nutritional sciences, School of Human Resources and Family Studies
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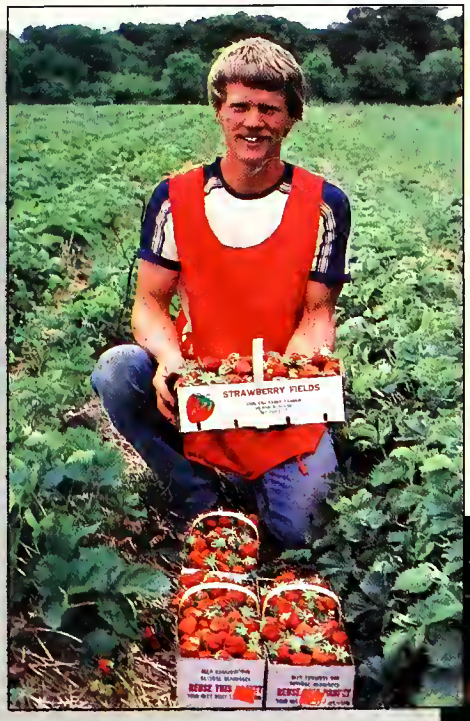
Marketing Horticultural Products

J.W. Courter and David J. Williams



Pick-your-own strawberry operation near Gilman, Illinois (above).

Horticultural crops are in an ironical situation in Illinois. It is ironic that although many of our horticultural industries rank high in regional and national arenas, their contribution to Illinois's agricultural economy is small by comparison. Illinois farmers grow over fifty vegetable and fruit crops. They lead the nation in the production of horseradish and pumpkin for canning and are significant producers of sweet corn and green peas for processing. Other important crops for Illinois include apples, asparagus, greens, lima beans, melons, snap beans, strawberries, and tomatoes.

Also ironic is the fact that even though Illinois is a major producer of horticultural crops, according to a study conducted in 1983, it grows only about 5 percent of the fruits and nuts, 11 percent of the vegetables, and 3 percent of the potatoes consumed in the state. It imports the balance from other states and many foreign countries.

At the same time, Illinois exports fresh vegetables, processed products, apples,

Each year record-breaking crowds attend the Illinois Fruit, Vegetable, and Irrigation Convention and Trade Show (right).

and nursery crops. For instance, it is a major exporter and importer of nursery and florist products. Woody landscape plants are shipped from and to both coasts and into Canada. Flowers are received daily from Israel, Columbia, Holland, and other foreign countries.

Specialty crops

Horticultural crops are considered specialty crops, not alternative crops, because there is no practical way to convert a significant number of acres of grain or soybean production to horticultural crops. Farmers who want to grow a horticultural specialty crop should consider the following factors carefully.

Intensive culture. Many horticultural crops are intensively cultivated. A large volume and potentially high gross returns are possible from small land areas. Special skills, machinery, and irrigation are required. Gross returns can be from $1,000 to $2,000 per acre or more for many vegetables, from $3,000 to $5,000 per acre for fruit, and up to $12,000 per acre for nursery production. Full-season protected cropping in a greenhouse can gross from $15 to $20 per square foot of growing space. But overhead costs, variable production costs, and the level of risk are high.

High management. Specialty crops require a high level of management. There is no substitute for highly knowledgeable and skillful managers in growing and marketing horticultural crops. Farms may grow one or two food crops or as many as 30 or more. Commercial nurseries grow as many as 250 crops. Diversification spreads management time and often increases risk.

Labor intensive. Many horticultural enterprises demand large amounts of labor for care, harvest, and market preparation. Nevertheless, one task that always tests a manager's skills is keeping this farm labor fully employed in growing a variety of crops throughout the season.

No surpluses. Virtually all horticultural crops are perishable or highly perishable. Surpluses take care of themselves, so no programs are needed to take excess production off the market. In fact, very few crops do not tend to be overproduced when weather is favorable or high demand and high prices create an incentive to produce more of the crop. Oversupply has a dramatic effect on fresh-market price. A rule of thumb is that a 2 percent oversupply will drop prices 10 percent and a 10 percent oversupply will drop them 50 percent.

Restrictions on location. Horticultural crops often have specific climatic or soil requirements that limit their production to favorable sites. Acid soils for blueberries and good air and water drainage for fruit and nursery crops are good examples. Close proximity to markets or processing plants are obviously important considerations too. Retail nurseries and garden centers thrive in urban and suburban locations that are usually very expensive real estate.

Consumer-driven demand. Marketers of horticultural products are highly sensitive to the demands of consumers, who ultimately determine what is grown and how it is prepared, processed, packaged, and marketed. The Illinois nursery industry for the past several years, however, has been in the enviable position of not being able to meet consumer demand, particularly for large landscape plants.

Changing markets. Shifts in the number, demographics, and preferences of consumers all influence the demand for horticultural products. Today, for example, consumers' concern for health and nutrition has increased consumption of fresh fruits and vegetables, especially salad vegetables, broccoli, and cauliflower.

The demand for landscape plant materials is also changing with an increased demand for herbaceous perennials, such as hostas and daylilies, and native plant materials, such as wildflowers and prairie grasses. Even the highway department and other public consumers are changing their planting specifications for right-of-way plantings from high-maintenance grasses and exotic ornamental trees and shrubs to low-maintenance prairie grasses and native trees and shrubs.

Market niche. Relatively few ready markets exist for farmers who are first starting out to grow a horticultural crop. In general, growers seek a special niche in the market by opting for an early harvest, freshness, better quality, an improved cultivar, a unique or improved package or process, or some other competitive edge.

Market diversity

Horticultural producers have a wide range of potential markets, depending on the location of their farm, size of operation, available transportation, and marketing skills. Individual farms may sell their products in more than one market.

A fresh market survey of the Illinois Vegetable Growers Association in 1987 found that over 70 percent sold vegetables directly to consumers and that more than 60 percent sold them wholesale to terminal markets other than those in St. Louis and Chicago. A majority thought their marketing strategies could be improved and that cooperative packing would improve sales and increase acreage under production.

Terminal produce markets. Growers have consigned fresh produce to wholesale firms at terminal produce markets for many years. The South Water Market is a major wholesale fruit and vegetable market in Chicago. Buyers who depend on terminal markets include some supermarkets, grocery stores, ethnic specialty stores, restaurants, hotels, institutions, and peddlers. Terminal wholesale markets are located in most major cities. Brokers at the South Water Market also specialize in carload lots of produce that are redistributed in the upper Midwest.

The wholesale houses for floricultural crops were concentrated in the 1300 block of Randolph Street in Chicago. These markets are now dispersed throughout the six-county metropolitan area of northeastern Illinois to provide better service for both the wholesale growers and the retail florists shops. The growers in southern Illinois market some of their products at the Wall Street Market in St. Louis, where six floricultural wholesale houses are located. No wholesale markets of this type exist for the distribution of woody landscape plants.

Food processors. The acreage of vegetables contracted in Illinois with food-processing companies has been declining

for many years. This trend may have reversed with the 1989 season. About 75 percent of the estimated 110,000 acres of vegetables are grown for food-processing companies. These companies contract for specified acreage and may provide scouting services and harvesting aid. Depending on the crop, they may also specify cultivars, pesticide treatment, and planting dates.

Among the firms contracting acreage in Illinois are Stokely USA, Inc.; Del Monte Corporation; Green Giant Company; Libby, McNeill, and Libby; Razorback Farms, Inc.; Hartung Brothers, Inc.; Red Gold, Inc.; Larson Company; and Green Bay Foods.

Chain store warehouses. Large supermarket chains purchase directly from producers who deliver to their warehouses. Dominick's Finer Foods, Inc. and Jewel Food Stores are two major food chains that serve Illinois and the metropolitan Chicago area. High quality, uniformity, proper precooling and packaging, and consistent supply are prerequisites for selling to these buyers.

In 1911, Herman B. Dorner, a professor of horticulture at the University of Illinois, served as the first secretary of Florists' Transworld Delivery (FTD) and was instrumental in the development of this unique marketing system.

Chain stores are major outlets for landscape plants. Many of the large chains, such as Sears, K mart, Frank's, and Walmart, have nursery or garden departments that sell a variety of plants and gardening supplies. Nationally, these four firms account for more than 1,400 million dollars in retail lawn and garden sales. Producers must consistently be able to provide prompt deliveries to many different locations in order to gain access to these markets. Many growers do not have the distribution capacity to service them.

Local stores and supermarkets. The policy of buying local produce varies widely and often depends upon the discretion of the local store manager. Local farmers must find their market niche to develop these opportunities. Produce managers, for instance, have often found good sales for home-grown, freshly picked strawberries and sweet corn delivered daily to local stores and supermarkets.

Restaurants and fast food stores. Farmers' ability to serve this market depends on their developing personalized service, making delivery on time, and providing the quality or special crop needed.

Farmer cooperatives. Successful in many areas, grower-owned cooperatives bring together small growers to enable the co-op to pack and ship larger quantities to wholesale markets. Several small co-ops market a limited number of crops, mainly vegetables, in Illinois. This type of marketing is not used for selling landscape plants in Illinois; however, small growers have banded together into informal cooperatives to buy larger quantities of supplies and plant materials so that they can benefit from quantity discounts.

Telemarketing. Unique to the marketing of floricultural products is telemarketing. A national network of retail flower shops is linked together by a telephone system that allows a consumer to order fresh flowers in a local flower shop and have them delivered the same day or within 24 hours almost anywhere in the United States.

Farmer-to-consumer markets. Community farmers' markets, roadside stands, greenhouses, garden centers, and pick-your-own farms sell directly to consumers who live nearby. These direct markets provide an opportunity for small farms, an entry into local markets for new producers, and alternative markets for large diversified farms. Each year the Illinois Department of Agriculture publishes the "Directory of Illinois Fresh Fruit and Vegetable Markets."

Rewholesalers. "Rewholesaling" is a "new" term now used to describe the traditional activities of nursery plant brokers. These marketers buy plant material from a variety of wholesale sources, usually in large quantities to take advantage of discounts and then to resell these products to landscape contractors, garden centers, and other retail outlets. Rewholesalers in Illinois include proprietorships and large corporate nurseries, such as the Weyerhaeuser Nursery Products Division, the largest U.S. rewholesaler.

Mail order nurseries. This type of nursery delivers nursery plants to its customers by the U.S. Postal Service or United Parcel Service. These companies advertise their products through catalogs and literature sent directly to their customers. A number of mail order nurseries operate, with Illinois as their home base.

Other markets. Growers in producing regions may sell directly to nearby packers or grower-shippers, who in turn ship to distant markets. Growers of herbs and other specialty items publish catalogs and advertise to mail order clientele. Some growers are able to develop market outlets with businesses, schools, hospitals, and other institutions. These highly specialized market opportunities are limited only by the imagination and ingenuity of the grower. Illinois does not have large produce auction terminals that provide a cash market in some other states.

Consumer Preferences

A recent study by the American Florists Marketing Counsel on consumer buying trends indicates that less than half of all flowers are bought at florists' shops (see accompanying pie chart). Regular purchases at supermarkets have grown at the expense of consumer loyalty to local florists shops, but a significant group of

consumers buys regularly at both outlets. This group represents an opportunity for proactive florists who aggressively pursue clients.

Meet the Buyer

Identifying and developing suitable markets are factors that limit horticultural production in Illinois. Market forces will continue to bring many changes, and we are optimistic that Illinois's resources of water, soils, and central location in respect to a large percentage of the U.S. population will provide increased opportunities.

The Illinois Fruit, Vegetable, and Irrigation Convention is striving to improve marketing knowledge and communication. This year, for example, the convention sponsored and promoted a "Meet the Buyer" program, through which farmers learned about potential crops from buyers with a number of companies.

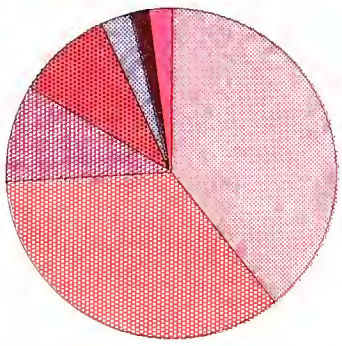
National Nursery Crops Survey

The University of Illinois Department of Horticulture is participating in a national survey of the nursery industry. Eighteen of the largest nursery-crop-producing states are compiling basic production and marketing data about their share of the $7-billion wholesale nursery industry.

Improved collection of statistical information about the kinds of crops planted, acreages, and the value and use of natural resources by Illinois horticultural industries is needed. If the Illinois Agricultural Statistics Service could provide this information, it would be an invaluable guide to future research programs of the Illinois Agricultural Experiment Station.

J.W. Courter, professor of horticulture and Extension specialist, small fruit and vegetable crops, Dixon Springs Agricultural Center, Simpson, Illinois, and David J. Williams, professor, Department of Horticulture

Where consumers buy flowers



Adapted from a study by the American Florists Marketing Counsel, 1989.

Farm Trade Areas: A New Concept in Direct Marketing

J.W. Courter

The principal market for 1,800 acres of small fruits in Illinois are consumers who live in nearby communities. These customers drive to pick-your-own (PYO) farms to get a quantity of berries, to select the best berries, and to save money. They choose one farm over another for the ease of picking, the price, and loyalty based on previous experience.

Among the most popular crops sold by Illinois PYO farms are strawberries, blueberries, raspberries, blackberries, apples, beans, peas, tomatoes, and greens.

Trade Areas for Agricultural Businesses

The concept of retail trade areas has been researched and defined for food stores and shopping centers for many years, but the idea has not been generally applied to agricultural businesses or farms.

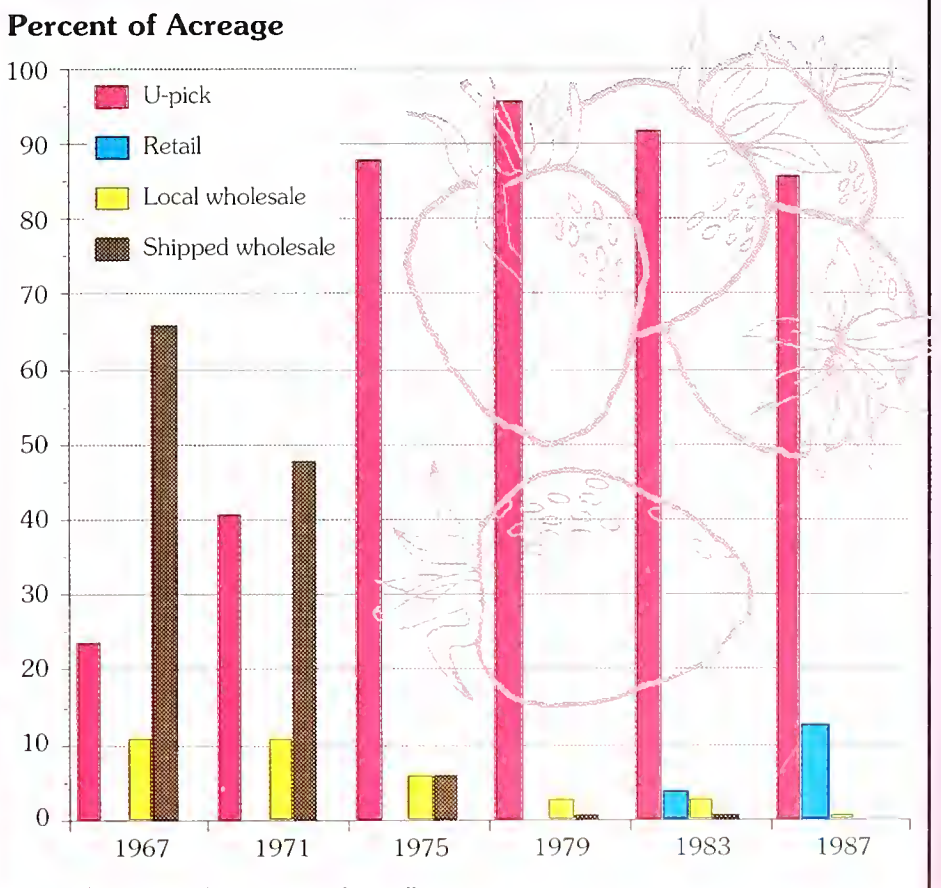
The trade area of each PYO farm is not a perfect circle surrounding the farm; it is where the farm's customers live. This area can be described geographically and delineated by access roads; mountains, rivers, and other natural barriers; and the location of competition. Poor and winding roads, limited travel routes, and long distances from populations deter consumers from picking their own. Farms with large trade areas are vulnerable to competition.

The primary trade area for an Illinois strawberry farm, for example, is the geographical area where 75 percent of all its customers live. They are the basis for repeat business. For strawberry customers, the average trade area is a 20-mile radius around a farm that sells strawberries.

In a statewide survey conducted in 1985, I have found that 71 percent of households bought fresh strawberries and that 19 percent picked their own. A higher percentage of households in rural areas picked strawberries than households in heavily populated metropolitan areas. I have also found that an acre of strawberries can be marketed to a rural population of 2,500 within 20 miles of the farm.

The ratio changes on operations near big cities: one acre of PYO strawberries for a population of 10,000. The difference in these ratios may be due to the fact that many city residents either do not know about the opportunity to pick their own or lack transportation. Of those who did not pick strawberries in the 1985 survey, 53 percent were not aware of the PYO opportunity. Marketing trends for strawberries in Illinois are shown in the accompanying figure.

Each farm, however, is unique, and crops other than strawberries have different yield and consumption patterns.



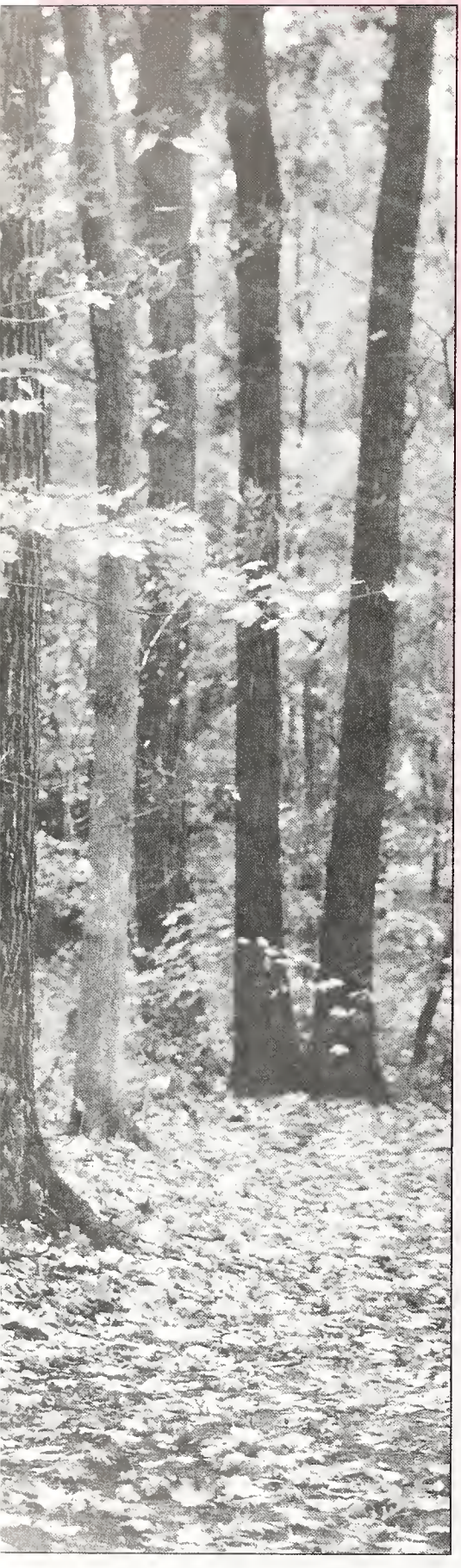
Strawberry marketing trends in Illinois

Projections Guide Marketing Decisions

Defining the trade area helps provide preliminary estimates for establishing a marketing plan. Farmers use trade-area projections to expand their present acreage, discover new opportunities, develop their advertising plans, and pinpoint overly competitive locations. If, for instance, 4 acres of strawberries require 1,500 or more customer sales, participation by 20 percent or more of all households living in a primary trade area of 10,000 people is required for a successful PYO venture.

Limited populations, therefore, will not support a large PYO acreage. Farms in these areas should only consider a PYO business as an opportunity to employ family labor and to supplement other income.

J.W. Courter, professor of horticulture and Extension specialist, small fruit and vegetable crops, Dixon Springs Agricultural Center, Simpson, Illinois



Illinois's forest resources — marketable assets.

Opportunities for Marketing Forest Products

Gene E. Campbell and Gary L. Rolfe

Typically what comes to mind when we think of forest products is lumber, Christmas trees, or firewood. Forest products, however, encompass much more. From the morning newspaper to the home we come back to in the evening, the average person uses or comes in contact with hundreds of products from the forest each day. These demands on our forest resources for fiber, food, and chemicals are expected to continue increasing as our population grows and as new forest products are developed.

In Illinois, 4.3 million acres or 12 out of every 100 acres are forested. Ninety-four percent of this forestland is classified as commercial timberland; and 90 percent of this timberland is owned by farmers and other private individuals.

With nearly 30 forest cover types, these private nonindustrial forests are very diverse, the most common type of forest cover in Illinois being a combination of oak and hickory. In 1985, 98 percent of the 4.8 billion cubic feet of timber growing stock was hardwoods.

Timber Products

Timber removals from growing stock in Illinois totaled 68.6 million cubic feet in 1984. This timber stumpage was cut into logs for veneer or lumber, pulpwood, fuelwood, posts, or other products. These primary forest products are used by the secondary manufacturing industries in the United States to produce the vast array of consumer goods in the marketplace today.

Some products are used in the manufacturing process itself: pallets, jigs, and packaging. Lumber is the product used in greatest amounts, followed by particleboard, plywood, bolts (rough timber), veneer, medium-density fiberboard, insulation board, and hardboard.

Hardwoods

The hardwood export market also is significant and increasing in importance. For example, between 1970 and 1986, U.S. exports increased by 102 percent for hardwood logs, 329 percent for lumber, 442 percent for veneer, and 611 percent for plywood. Much of this increase has been for white and red oak products in the European market and in the expanding Asian market.

In 1986, 688 million board feet of hardwood logs and lumber, and over a billion square feet of hardwood veneer and plywood were exported. Major importing countries were Canada and West Germany, with increasing exports to Japan and Taiwan. Significant amounts of hardwood are also exported to Belgium, the Netherlands, France, Switzerland, Great Britain, Denmark, Italy, and Mexico.

Opportunities for Expansion

For the last 10 years, Illinois has ranked in the top five states in the use of forest products, but its manufacturing industries import nearly 70 percent of this wood from other parts of the country. Much of the imported wood is hardwood. An excellent opportunity, therefore, exists for substantial expansion of forest product markets available to owners of Illinois forestland. This expansion, which would

benefit both the primary and secondary wood-using industries of the state, could be achieved in a number of ways.

Increasing the supply of timber. One method of creating more forest product markets is to increase the supply of timber. An immediate increase could be obtained by simply increasing the timber harvest. It is estimated that only one-third of annual forest growth is harvested and processed by the primary industries in Illinois. Short- and long-run supply could be enhanced by increasing seedling production, selecting genetically superior seedlings, converting marginal agricultural land to forestland, improving timber management and harvesting practices, and increasing wood utilization.

Increasing primary manufacturing. This increase could expand markets for forest products by making more of Illinois forest resources available for secondary manufacturing. In particular, the capacity of dry kilns must be increased, and the utilization of sawmill wood must be improved. These steps would significantly increase the production of high-grade lumber from Illinois's forests.

Compared to surrounding states, Illinois has relatively high workers' compensation, unemployment insurance, and utility rates as well as high truck license fees. Making these more equitable would encourage more forest industries to settle in Illinois.

Increasing marketing efforts. Marketing efforts must be increased. Forest products harvested in Illinois are often manufactured and marketed in such a way that landowners, loggers, sawmills, and other wood-processing firms receive less than full value for their products.

Steps to improve marketing include owners' obtaining multiple bids when selling timber and their planning timber sales to coincide with favorable market periods. Greater knowledge of proper wood utilization and marketing techniques also is needed, as are better knowledge of and access to sources of investment capital. In addition, markets for low-quality and fast-growing trees must be improved by developing new products and promoting on-farm energy use of forest biomass and other uses of forest products.

Knowing about nonwood forest products. Wood products are not the only commodities produced in the forest. By producing forest-related nontimber products, such as ginseng and shiitake mushrooms, and expanding recreational opportunities, forest product markets can be diversified and expanded further.

With current technology, we can significantly improve marketing opportunities for Illinois forest products. Through proper market development, Illinois will benefit more fully from utilization of its forest resources. Advances in biotechnology, improved utilization, and product development will increase these opportunities and benefits.

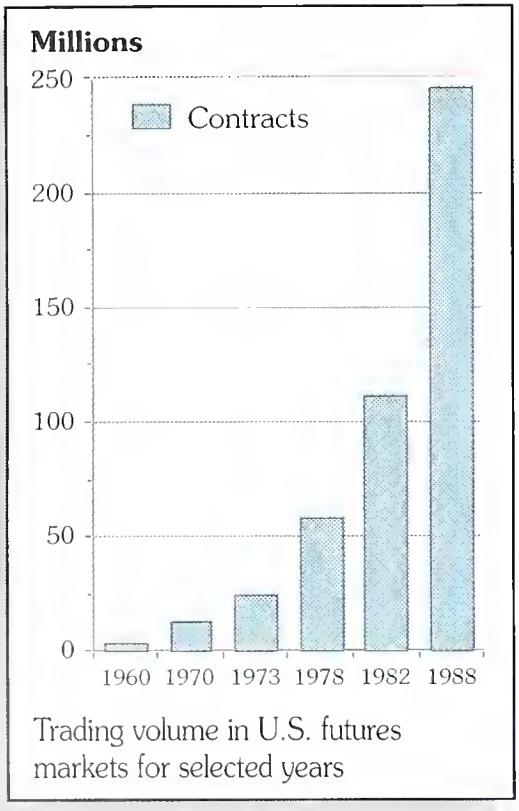
Gene E. Campbell, assistant professor, and Gary L. Rolfe, professor and head, Department of Forestry

Lumber, wood chips, and dowels are only three of the many forms that forest products take.

Commodity Futures and Options Markets: Tools of the Trade

Philip Garcia, Raymond M. Leuthold, and Robert J. Hauser

Only about 2 percent of futures contracts are ever held to maturity and liquidated by delivery. Why then have the futures markets been such an integral part of our economy and agricultural marketing system? Why, for example, have the futures markets in Chicago been in existence for more than 125 years? These markets not only exist but also continue expanding because they help our economy and agricultural marketing system to function more effectively.



Trading volume in U.S. futures markets for selected years

Traditionally, futures contracts existed for only storable agricultural commodities and metals, but in the mid-1960s, the markets expanded to include nonstorable livestock commodities. This expansion was followed by the introduction of contracts for foreign currencies; treasury bills, bonds, and other financial interest-rate instruments; petroleum products; and stock indexes, among others. Since 1984, we have seen the introduction of options on many of these futures contracts. Currently, futures and options markets in the United States are global in nature, and futures exchanges are exploring methods to extend trading hours to 24 hours a day around the world.

The accompanying chart demonstrates the tremendous growth in futures trading over the last three decades. The total face value of all futures and options contracts now traded amounts to several trillion dollars annually.

Mechanics of Trading

About three-quarters of U.S. futures contracts are traded in Chicago, either at the Chicago Board of Trade or at the Chicago Mercantile Exchange. The exchanges provide the facilities and rules for organized trading of contracts.

The contracts themselves are an agreement between a buyer and seller to exchange a well-defined commodity or instrument at a fixed price in the future. They are easily liquidated though offsetting transactions. Almost every aspect of a futures contract — including its size, the delivery site, the quality of the commodity, and the month of maturity — is highly standardized.

At the time a contract is created, no title changes hands, and only minimal amounts of money are posted by both sides to guarantee performance. Although only exchange members can trade futures contracts on the trading floors, trading is open to and done by the public through brokerage houses. Traders might be either speculators absorbing price risks or hedgers using the markets to forward price and manage risks.

Trading of futures and option contracts also is regulated by the federal government. Federal regulation is carried out by the Commodity Futures Trading Commission (CFTC), a five-person administrative body appointed by the President. Its primary purposes are to ensure proper execution of customer orders; to prevent or curb unlawful manipulation, price distortion, fraud, cheating, fictitious trades, or misuse of customer funds; and to assure the general solvency of the system. Together, the exchanges and the CFTC keep futures trading competitive, and relatively free of price fixing and collusion.

Functions of the Futures Markets

An important institution for many U.S. commodities, futures markets are extensions of the cash markets. Having evolved out of existing market forces, they make cash markets work better. They help forward price commodities and instruments

Buyers and sellers respond to changing market conditions.

— a speculative, unavoidable process in marketing. By establishing a price for the commodities or instruments to be sold in the future, the markets augment the degree of certainty in business decisions. Markets also shift risk and disseminate information — critical economic functions that facilitate the production and marketing of many commodities. In addition, they can facilitate the securing of capital.

Forward pricing. One of the most important functions performed by the futures market is the pricing of agricultural commodities. Prices are discovered by the market activities of many buyers and sellers through a public exchange of bids and offers. They reflect the market's information about actual and expected supply-and-demand conditions. In effect, they provide the market's expectations about subsequent cash prices.

For grains, current prices are closely linked to future prices through the price of storage. For nonstorable commodities, futures markets directly provide their view of future supply-and-demand conditions.

In addition, futures markets have fostered the development of numerous sources of information about actual and expected supply and demand — information that can be extremely useful to producers and other market participants in coordinating their activities.

Determining the size of inventories. Effective price discovery is particularly important for the activities of agricultural markets and their users. For grains and other commodities that are seasonally produced, price discovery can facilitate the carrying of inventories. For these commodities, producers, inventory holders, and speculators interact to form forward prices based on expected supply-and-demand conditions and on current supplies to ensure that existing stocks are rationed throughout the year.

Integrating commodity production and marketing. Producers and other market participants can use futures prices as a guide for decisions about production and marketing. Using current futures prices as expectations of subsequent cash prices, they can allocate their resources to what they perceive as their most productive activities.

Futures prices can also be used in conjunction with other marketing arrangements to establish cash prices for commodities to be delivered or received in the future. A flat-price contract based on the futures market price for later delivery is one such mechanism. More commonly,

cash prices are tied by a fixed differential to the futures price at maturity.

Risk management. A closely related function provided by futures markets is shifting the risk involved in owning a commodity. Owners run the risk that its value will decline; purchasers of inputs are concerned that their prices may increase. Trading activities through the use of futures contracts and options provide producers and marketing firms with the opportunity of reducing the riskiness of their operations. These markets allow producers and merchants to reduce the effect of price fluctuations by enabling them to establish a value for their outputs and inputs and to transfer at least part of the price risk to someone else.

Shifting risk with futures contracts is done through "hedging." Hedgers sell a futures contract if they own the commodity or buy a futures contract if they expect to purchase the commodity. For example, a producer's price of corn can be hedged by selling a futures contract. The hedge exists because the producer has opposite positions in the cash and futures markets — the producer owns corn in the cash market and has sold it in the futures market.

Because the cash and futures prices tend to move together, their offsetting positions cause the gains in one market to be close to the losses in the other. A decline in the general price level of corn causes a decline in the value of the cash inventories. This decline, however, is at least partially offset by the associated gain in the futures market because the hedger can buy the futures contract at a lower price than its original sale price.

The extent to which these activities can completely eliminate price risk depends on the difference between the expected and actual basis at maturity — the futures price less the cash price. This difference is called the basis risk. Generally, however, the basis risk is smaller than the risk associated with movements in the general level of prices, making hedging an effective mechanism for reducing the variability in returns.

Although hedging by means of futures contracts can reduce variability in the value of a commodity, it also can limit the user's ability to gain from favorable price movements. In contrast, options present the holder or purchaser of a commodity the opportunity to set price floors and ceilings, while maintaining the possibility of capturing favorable price movements.

Options contracts provide the buyer the right, but not the obligation, to buy or sell an underlying commodity for a specific price in exchange for the payment of a premium. For example, a producer can buy the right to sell the underlying commodity at a specified price. If the cash market price is below the specified price, the producer exercises his option; if the cash market price exceeds the specified price, the producer simply sells on the cash market because the option is no longer of value.

Hence, options contracts can offer an "insurance coverage" that assures specified or base prices while allowing buyers of the contract to take advantage of favorable price movements in cash markets. Like all insurance coverages, however, there is a cost. In the case of setting price floors, as the hedger increases the minimum price, the likelihood of receiving a price above the minimum decreases. As the price floor is lowered, the opportunity for receiving higher prices increases.

Financial implications. The use of futures exchanges to manage risk can have implications for the financial constraints of the producer or market participant. Trading activities can effectively stabilize income or truncate the unfavorable distribution of returns. This security in the value of the commodity can lead to increased willingness on the part of lenders to loan additional funds for operating capital or longer term investments under more attractive financial conditions.

Performance

Controversy has always surrounded futures markets and their impact on other markets and prices. Questions about how well they perform their economic functions, their effect on cash prices, and their contribution to society's welfare are frequently raised by producers, politicians, and academicians. Here, we concentrate on the ability of these markets to incorporate information in price discovery and their usefulness in reducing risk.

How accurate are the markets' forward prices? How appropriately and quickly do futures markets incorporate new information? Do opportunities for speculative profits over extended periods exist? These questions have been the

subject of numerous research investigations. The results are somewhat mixed but indicate the potential usefulness of these markets in setting forward prices.

Forecast accuracy. The accuracy of forecasting subsequent cash prices by futures markets improves as the time horizon of the forecast shortens, that is, when closer to maturity. In a relative sense, futures market prices for grains, soybeans, and other semistorable commodities appear to be better forecasters than livestock futures markets.

Recent work on the relative forecast accuracy of livestock futures markets suggests that futures markets do a good job of forecasting for short horizons. For longer horizons from 4 to 6 months, research indicates that this market is not effectively incorporating all available information, especially for hogs.

As might be expected, during unstable periods, futures markets are not as effective in forecasting subsequent cash prices. But evidence suggests that it is difficult to generate statistical models that outperform the market in these unstable periods.

Effectiveness at registering and disseminating new market information. Prices in agricultural markets are highly interactive, yet examination of lead-lag relationships between futures and cash markets suggests the importance of the futures markets in short-term price discovery. Often, the highly organized futures markets are the first to register new information. Changes in prices are then effectively transmitted to the cash markets with only short delays. Recent work in the hog markets suggests that futures markets respond rapidly to unanticipated changes in market information.

Effectiveness of futures markets and options in reducing risk exposure. Several empirical studies have examined whether hedging, primarily by agricultural producers and first handlers of the commodities, reduces risks while maintaining income levels or if it increases income without increasing risks. Simple hedges reduce risk but frequently at the expense of income-generating opportunities. But more sophisticated hedging strategies that focus on locking-in only profitable alternatives have shown to be useful in reducing risk while maintaining acceptable income levels. Recently, hedging strategies based on effective forecasting techniques have resulted in even more attractive market returns.

The limited work on the effectiveness of options in reducing exposure to risk suggests that the largest benefit from hedging with options stems from the numerous risk-return combinations available. These different combinations can be created by varying the price floors or ceilings, timing, and other factors of the hedge. The mere existence of increased hedging opportunities has been shown to be beneficial to the agricultural industry.

Futures markets improve the scope and flexibility of decision making for a firm. They serve a useful economic purpose and continue to exist because of support from commercial firms that need to manage risks and make decisions. Futures markets are a facilitating and coordinating market mechanism for decision making, price discovery, risk management, and the collection and interpretation of information necessary in the allocation of scarce resources. Their importance to effective decision making in the agricultural sector is difficult to overstate.

Philip Garcia, professor; Raymond M. Leuthold, professor; and Robert J. Hauser, associate professor, Department of Agricultural Economics

A Tribute

Raymond G. Cragle

1926-1989

Raymond G. Cragle, professor of animal sciences and international agriculture and former director of the University of Illinois Agricultural Experiment Station (1978-1983), died in Peshawar, Pakistan, on June 30, 1989. Cragle, 63, was working there at Northwest Frontier Province Agricultural University (NWFP Agricultural University) for the U.S. Agency for International Development, the University of Illinois, and Southern Illinois University. He was team leader of the Transformation and Integration of the Provincial Agricultural University Network (TIPAN) project.

Cragle's colleagues may use many words to describe his life, but they all sum up his achievements in the same way: Cragle was a dedicated, innovative, and intense individual. He was a visionary, a catalyst, a man devoted to excellence.

"His greatest quality was his single-minded determination that change could be affected in a very tradition-bound society," said Thomas McCowen, associate director of International Agriculture at the University of Illinois at Urbana-Champaign. "He always believed the best instincts of people would cause them to work together to solve common problems. He felt agriculture was basic to the development of any country, whether this one or a developing nation."

At the time of his death, Cragle was applying his vision and energy in Peshawar, Pakistan, where he "tried to apply both science and the interpersonal management skills that he had acquired to help in the transformation [of NWFP Agricultural University] into a more dynamic organization that would reach out to farmers — mostly poor farmers," according to McCowen.

"He made some major contributions in Pakistan," trying to get the NWFP Agricultural University to adopt the philosophical approach of the land-grant mission — bringing together teaching, research, and extension, said William George, currently an associate dean and director of resident instruction in the College of Agriculture. According to George, who spent a month with Cragle in Pakistan in 1986 and had worked with him when he was at the Illinois Station, Cragle was concerned about doing something for diverse groups of people — farmers, commodity groups, ag groups, and faculty.

He had great empathy for the users of research information. He felt that researchers themselves were the best ones to integrate their knowledge and the results of their research into useful applications, so he urged the faculty to think in terms of solving problems, not in terms of supplying unintegrated information.

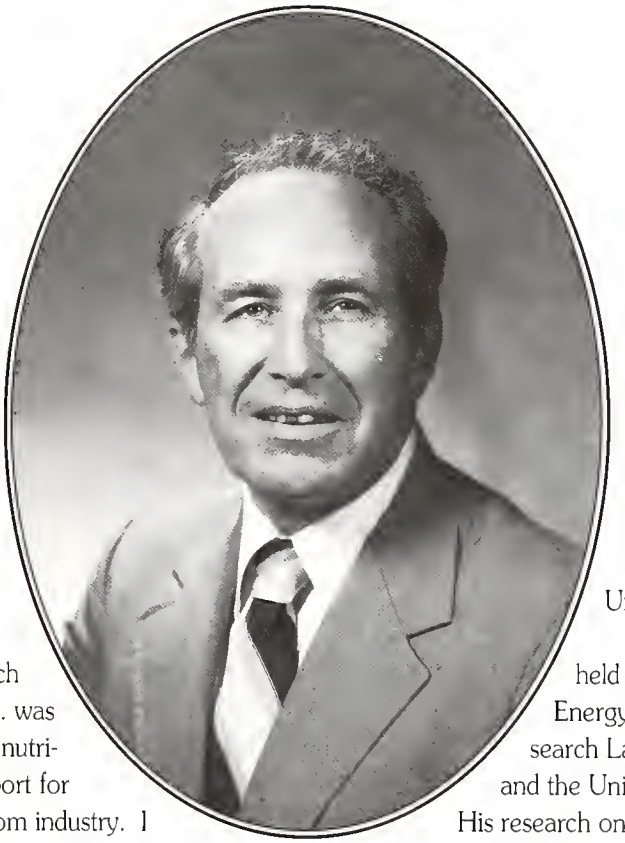
Harvey Schweitzer, assistant director of the Station, remembers Cragle as being "tremendously courteous. He had an ability to handle difficult situations and assignments.

"He was always thinking of ways to improve the Station. He encouraged departments and researchers to seek outside funding to support Hatch money." (The Hatch Act of 1887 authorized a system of experiment stations to be set up in land-grant colleges.) One of his lasting contributions to the Station was a plan for future outlying research and demonstration centers. The study he led still provides the basic framework for our field research.

Cragle can also be remembered for establishing a structure to provide leadership and direction for programs at the Station so that it could determine what programs to support, according to Douglas Bauling, assistant to the director of the Station.

"The Station identified water quality and erosion as important areas of research, and it turns out that those issues are important today," Bauling said. "Ray was never one to avoid controversy. You can't fault him for not trying — he put a lot of effort into everything he did."

Glenn Salisbury, who was Cragle's predecessor at the Station and also Cragle's teacher at the University of Illinois had this to say about him: "I heard about a young man finishing a master's degree who was well-trained in biological statistics and wanted to work with me. I was head of the Department of Dairy Science. He was an outstanding dairy student. I was impressed with him as a youngster — as a young man. He had lots of ambition, lots of promise."



Arthur Siedler, head of the University of Illinois Department of Food Science, is grateful that Cragle was such a leader: "One of [his] contributions ... was developing a food science and human nutrition funding drive that resulted in support for these programs ... some $300,000 from industry. I felt he understood research and was a strong proponent of its development."

Gary Rolfe, who was assistant director at the Station under Cragle and now the head of the Department of Forestry, remembers Cragle as "one who truly worked toward modernization; for example, he wanted more computerization, computer systems for information bases."

Rolfe recalled that Cragle hired a designer to develop the office into a more efficient and pleasant working place for his staff, a move that invited criticism, "because we all got new furniture."

Rolfe said, "He truly cared about people and was supportive. He was very interested and concerned about understanding everyone's position, although some didn't think so. He served as a catalyst to make things happen. He was a man before his time in many ways."

Staff members of *Illinois Research* especially remember this intense, energetic person for commissioning the quarterly's new design and for hiring a half-time graphics director. Every issue carries this quotation from Cragle, which embodies his philosophy and that of the Station: "At a time unlike any in the past, we must envision the future."

Cragle received his B.S. in 1951 and his M.S. in 1954 in Animal Industry from North Carolina State University. He earned his Ph.D. in Dairy Science from the University of Illinois at Urbana-Champaign in 1957.

He returned to the University of Illinois in 1978, as director of the Station. Before that, he was head of the Department of Dairy Science at Virginia Polytechnic Institute and State University from 1970.

In the 12 years preceding 1970, he held a joint appointment at the Atomic Energy Commission's Agricultural Research Laboratory in Oak Ridge, Tennessee, and the University of Tennessee at Knoxville.

His research on dairy cows during this period included physiology and nutrition; metabolism of fission products; the effects of lethal and sublethal gamma and neutron radiation; mineral metabolism; the gastrointestinal absorption and secretion of mineral elements; chimerism in large animals (creating individuals containing cells derived from different zygotes); and kidney transplants and skin grafts in chimeric cattle.

Cragle was a member of the American Dairy Science Association, the American Society of Animal Science, the American Institute of Nutrition, the Transplantation Society, the Society for the Study of Reproduction, and the American Association for the Advancement of Science.

He was named as an Outstanding Educator in America in 1971. He has also been recognized in *American Men and Women of Science, Leaders in American Science, Who's Who in the South and Southwest*, and *Who's Who in America*.

He was also very active in the Presbyterian Church and the Boy Scouts of America.

Born in Orangeville, Pennsylvania, Cragle is survived by his wife, Phyllis; three children, daughter Donna and sons Mark and Matthew; three grandchildren; and two brothers, Edward, of Millville, Pennsylvania, and Larry, of Forty Four (Izard County), Arkansas.

Benjamin A. Jones, Jr., associate director of the Illinois Agricultural Experiment Station

In Progress

The Chinese Pigs Have Arrived!

After 10 years of planning and preparations, the Chinese forerunners of what is hoped will be a breed of "super pigs" finally arrived at the University of Illinois College of Agriculture on July 27, 1989. The 46 animals are part of a research project that could have a $78-million positive impact on Illinois pork producers.

According to David G. McLaren, the assistant professor of animal sciences who heads the project, the animals resulting from selective breeding with the Chinese swine are to have the best traits of the Chinese breeds and certain U.S. breeds: the super pigs would breed as early, have litters as large, and be as docile and hardy as the Chinese animals, but they would produce meat at least as lean as that produced by current U.S. swine breeds.

The Chinese breeds being studied are too fat for U.S. markets. Porcine somatotropin, a recombinant growth hormone, however, may be useful in reducing the fat in offspring of these pigs. University of Illinois studies have indicated that somatotropin can reduce carcass fat by up to 40 percent in market weight hogs.

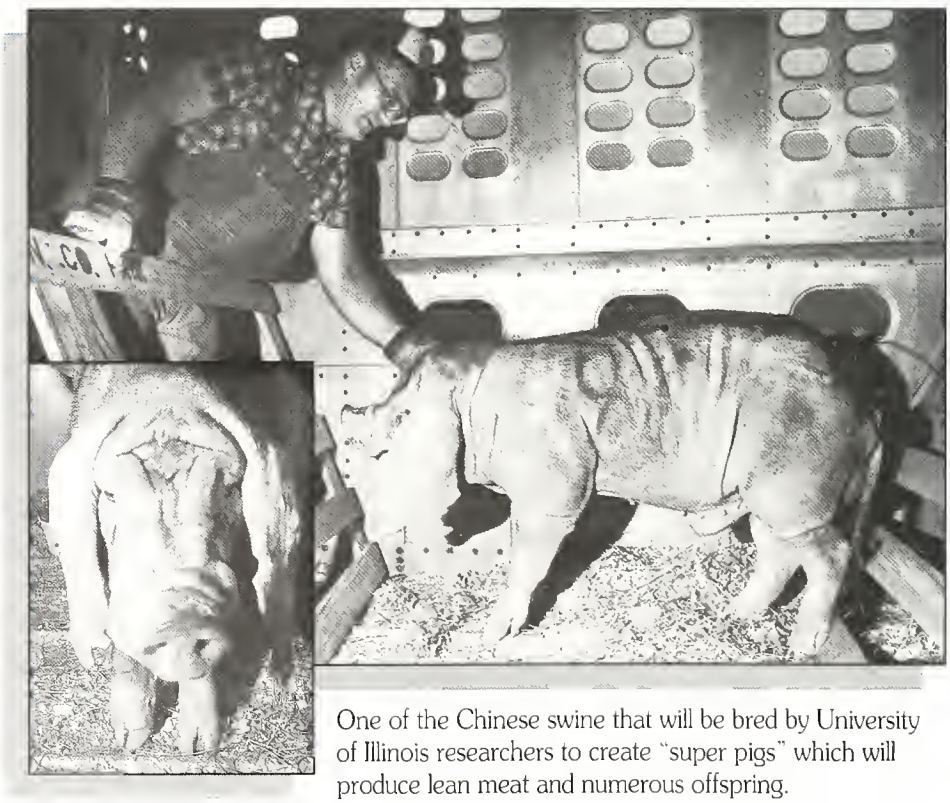
The 46 Chinese pigs are the University of Illinois's share of the 140 swine imported this spring from the People's Republic of China. The others were sent to Iowa State University and to the U.S. Department of Agriculture (USDA) Meat Animal Research Center in Nebraska. All of the pigs spent their first 120 days in the United States in quarantine at a USDA facility in Florida. The University of Illinois's 21 Meishan gilts and 10 Meishan, 8 Fengjing, and 7 Minzhin boars will be studied in a $1.75-million facility completed earlier this year. McLaren estimates that the University of Illinois's share of transportation and related costs for the pigs will be $500 thousand and that it will require about $1 million over 5 years to operate the research project, which will involve over a dozen researchers.

This project could dramatically affect pork production in Illinois. The average litter size of the imported Chinese sows is 15 piglets; U.S. sows average considerably less. Improving the average number of pigs weaned in U.S. litters from 8, the current size, to 11 could save producers an estimated $9 per pig produced. Given that Illinois annually produces about 8.7 million pigs, this savings means an additional $78 million for Illinois producers.

But, they should not expect to see the progeny of these Chinese pigs on Illinois farms in the near future. The study will take an estimated 5 to 10 years, and it will be at least 5 years before any of the Chinese pigs are sold to commercial producers.

The only place outside of China that these breeds have been studied is France. According to McLaren, data from that project suggest that our breeding efforts may be successful: a sow that is only half Chinese and half Large White is still as prolific as the full-blooded Chinese sow.

McLaren has noted that it is important for U.S. pork producers to improve efficiency: " Poultry consumption has doubled in this country since the 1950s, in large measure due to more efficient means of production. U.S. farmers must produce pork more efficiently in order to keep pork competitive. The research on these Chinese swine could help U.S. producers do just that. □



One of the Chinese swine that will be bred by University of Illinois researchers to create "super pigs" which will produce lean meat and numerous offspring.

Newsletter Focuses on the Ecology and Sustainable Agriculture

"Agro-Ecology news and perspectives," a bimonthly newsletter, will debut in September. In each issue, faculty from the College of Agriculture and a guest writer will address the physical, biological, socioeconomic, and political aspects of Illinois agriculture within the context of ecology and sustainability. The newsletter will keep readers abreast of agricultural issues, research and educational programs in the College of Agriculture, and upcoming conferences, workshops, seminars and lectures.

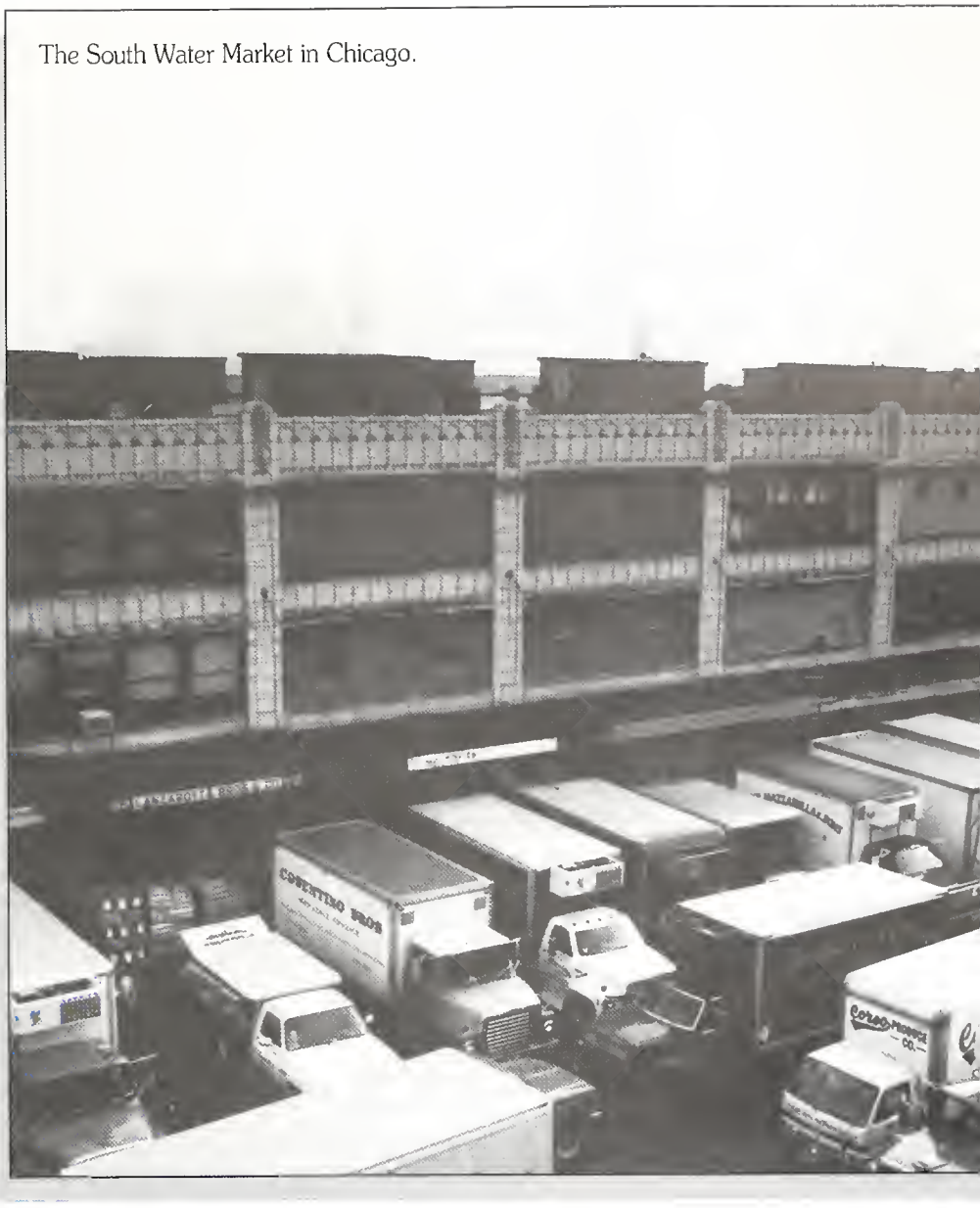
To receive a free copy, please write:
The Editors,
AGRO-ECOLOGY
news and perspectives
College of Agriculture
211 Mumford Hall
1301 West Gregory Drive
Urbana, Illinois 61801

New Directory To Link Growers to Markets

Low commodity prices in the 1980s have made diversifying farm production with alternative and specialty crops more appealing. Along with carefully researching the details of growing one or more of these crops, Illinois producers need to analyze marketing factors, such as where to sell the crop, how to locate potential buyers, and how to set the product's price. Grain farmers, livestock producers, and landowners who have had difficulty in finding markets and establishing prices for these crops should watch for the release this fall by the Illinois Cooperative Extension Service of a marketing directory for alternative and specialty crops.

To help them identify opportunities for these crops and find access to the marketplace, this directory will inform growers how to establish initial contacts with buyers and acquaint growers with the pricing, packaging, and quality standards of different crops.

The South Water Market in Chicago.



One section, for instance, will list major produce markets in the St. Louis and Chicago areas and in various locales throughout Illinois. In addition to providing a buyer's name, address, and telephone number, each entry will indicate that buyer's desired specialty crops, unusual requirements, or other relevant marketing information.

Another section will give practical information about produce items, detailing federal quality and condition grades; quality characteristics that have commercial relevance; storage, handling, packaging, and shipping suggestions; and typical harvest periods. A description of seasonal price fluctuations over several years will accompany each crop.

A glossary of marketing terms, a list of food processors in Illinois and accessible areas in adjoining states, and a table of average net weights for different packaging containers will be included. Together the sections will constitute a powerful resource for Illinois growers who are examining the possibility of setting aside some acreage for specialty or alternative crops.

The directory will be available later this year. Address inquiries to Gail Snowdon, Office of Agricultural Communications and Education, 55 Mumford Hall, 1301 West Gregory Drive, Urbana, IL 61801; (217)244-2835.

Station Publications Recognized

Once again, several Illinois Agricultural Station publications have earned national, international, and local recognition. In June, the *World Bibliography of Soybean Entomology* by Jenny Kogan, Marcos Kogan, Ellen F. Brewer, and Charles G. Helm received the 1989 Eunice Rockwood Oberly Memorial Award at the annual conference of the American Library Association.

One of only two U.S. awards for bibliographies, the Oberly biannually gives national recognition to a bibliography in an agricultural or related science. Bibliographies are judged for their accuracy, scope, usefulness, format, and special features, including explanatory introductions, annotations, and indexes.

The culmination of 7 years of painstaking research, the *World Bibliography of Soybean Entomology* provides over 25 pages of introductory material. Six indexes in a second volume facilitate access to its over 5,000 entries. To order a set, write to Publication Sales, University of Illinois Office of Agricultural Communications and Education, 69 Mumford Hall, 1301 West Gregory Drive, Urbana, Illinois 61801. The telephone number is (217)333-2007. Each two-volume set is $65.

The University of Illinois Office of Printing Services has informed us that it has been cited for printing excellence this spring and summer for its work on *Illinois Research*. The production and printing of the issues on the centennial and the human environment (Vol. 29, No. 4/Vol. 30, No. 1 and Vol. 30, No. 2) earned first-place awards from the In-Plant Management Association and the Champaign-Urbana Ad Club.

Judging criteria for the first award included printing definition, ink coverage, register, design, typography, degree of difficulty, and overall excellence. Entries by Canadian and Mexican printers competed with those submitted by U.S. printers for this award.

The same two issues won local recognition from the Champaign-Urbana Ad Club in the category of Best Public Relations — In-House Journals. Printers and ad agencies from Champaign, Urbana, and other nearby communities submitted hundreds of entries for media and publications work done for local businesses and institutions.

□

From Our Mouse to Your House: The New Look of *Illinois Research*

After receiving the last issue, several of our readers have commented that they liked the illustrations and graphic treatment, which are part of this quarterly's new look. Because of these comments, we thought you might appreciate seeing how the magic of desktop publishing *Illinois Research* works.

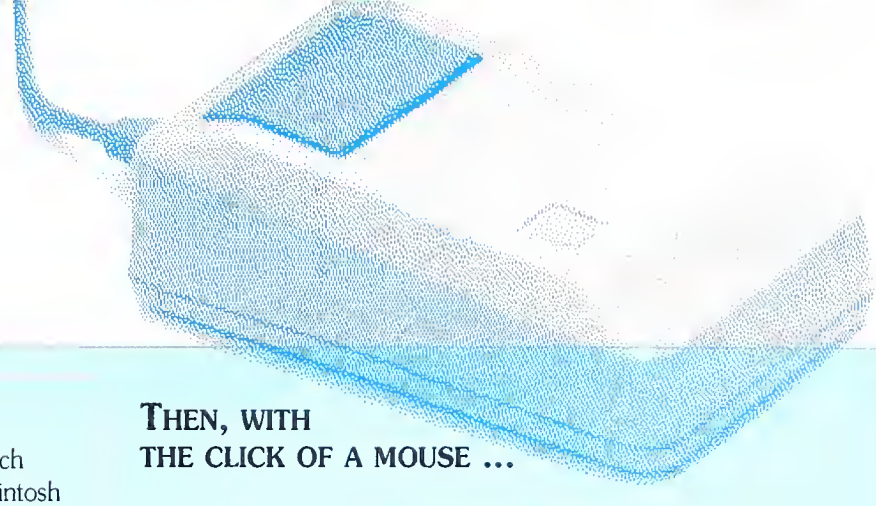
Since our graphics director, Paula Wheeler, replaced her drawing board, triangles, and pens with a Macintosh computer in February 1986, she has kept informed about the latest updates in software programs and hardware and has explored the limits of this new technology.

The current issue, for instance, was produced on an Apple Macintosh IIcx, with an 80 meg internal hard drive, 4 meg of RAM, and a Radius single-page display monitor. The following chart shows the flow of graphic production for this issue.

The desktop approach to publishing has eliminated the true galley stage along with the pain formerly associated with making corrections and adjusting the layout. Illustrations and screens no longer have to be stripped into the paged negatives

by the printshop. Eliminating conventional typesetting, paste-up, and some of the stripper's hand work has facilitated the production and printing that bring *Illinois Research* from our mouse to your house.

The editor



File conversion

IBM WordPerfect 4.2 files are converted on 3 1/2-inch high-density disks at Wheeler's workstation into Macintosh Microsoft Word format, using the Apple File Exchange utility and a MacLink Plus translator.

Then, with the click of a mouse ...

Illustrations

Wheeler generates full-color process drawings and charts with AppleScan, Claris MacPaint, Adobe Illustrator 88, and Cricket Graph. Then, she saves them in MacPaint, PICT, or encapsulated PostScript (eps) format for importing, sizing, and modifying in the paged document.

Importing text

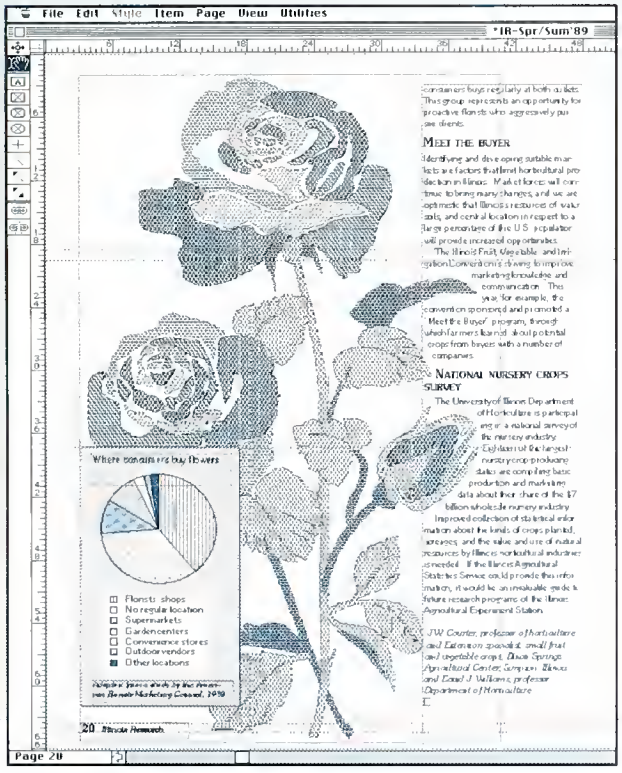
QuarkXPress, a sophisticated page-layout software program, is used to format the text in Souvenir typeface. Body copy is 10.5 point size at a 90 percent "horizontal scale" (width) with 13.2 point leading in a grid of three 14-pica-wide columns. Wheeler runs the spell checker and indicates preferences for hyphenation and other parameters. She saves a lot of time also by using text style sheets. Character spacing is adjusted by "tracking" entire groups of words or "kerning" between individual letters.

Photographs

Photos get special treatment. They are surrounded by a 1.2 point frame and have a 38 percent black screened shadow box. Portraits have windows inside oval frames created directly in the page layout. The printed frames also serve as the keyline for final slide placement. For the sake of better quality and computer memory, however, the printshop separates the final color slides and inserts the negatives into position.

Backgrounds

Graduated color backgrounds are created in a full-color process, using Adobe Illustrator 88. These blends are saved as eps and then imported into the page for placement and sizing. QuarkXPress excels in controlling both detailed color separations and complicated screen combinations.



Rough layout

Imported graphics magically meet the text in QuarkXPress. Images are sized and placed directly onto the page for a preliminary layout. Many versions of the layout may be explored before the final order of the articles is selected. Page proofs are produced with an Apple LaserWriter Plus, a 300-dots-per-inch (dpi) printer. Thumbnails are also printed to show the balance among the text, graphics, screens, and color. Corrections are then easily made, and final layout determined.

Camera ready and more!

Professional camera-ready artwork is prepared on disk and sent for Linotronic output with a resolution of 1,270 dpi. By placing all the illustrations and separating the colors herself, Wheeler has also eliminated some of the hand work formerly done by the printshop. Each of the color plates is delivered to the printshop in the form of film negatives with illustrations, reverses, screens, registration marks, and crop marks — all in position.

University of Illinois at Urbana-Champaign
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Urbana, IL 61801

Illinois Research

Fall/Winter 1989

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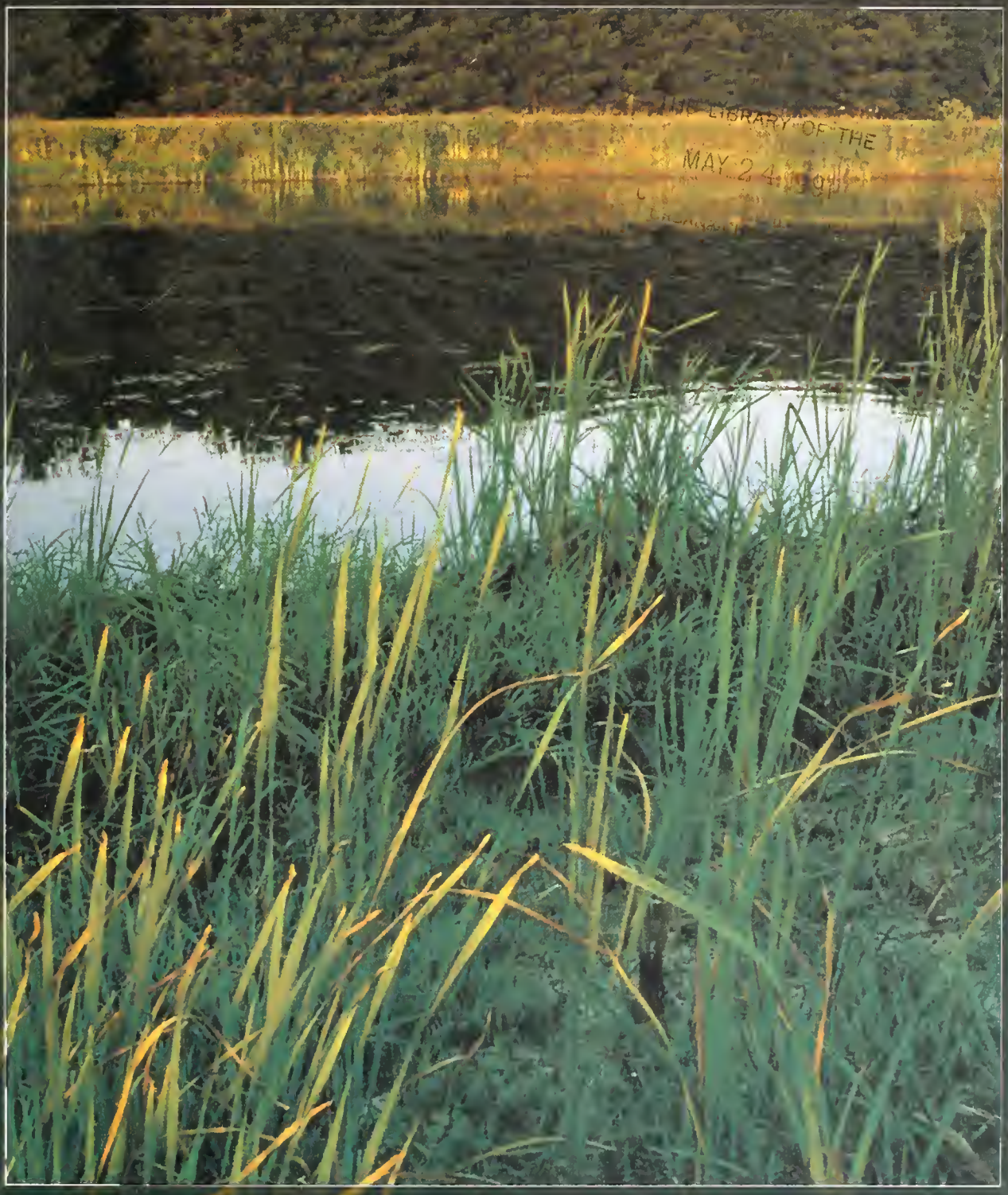
Agricultural Experiment Station
Fall/Winter 1989

Sustainable Agriculture



College of Agriculture, University of Illinois at Urbana-Champaign, Volume 31, Numbers 3/4

The Cover

Wetland at the Brownstown Agronomy Research Center.

"At a time unlike any in the past, we must envision the future."

Illinois Research

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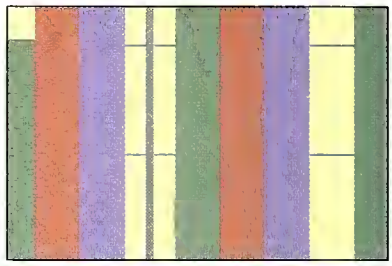
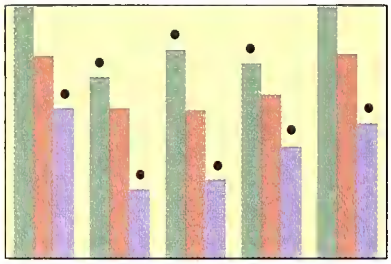




This issue of *Illinois Research* is printed on recyclable paper.

Sustainable Agriculture: Emerging Technologies and Practices

Harvey J. Schweitzer

Anyone involved in farming, agribusiness, agricultural education, or related research is well aware of the dynamic nature of agriculture. Within a century, American agriculture has progressed from dependence on horsepower and human labor to become a highly industrialized sector of our economy. American agriculture has moved rapidly through a mechanical age and a chemical age and has now entered a biological and ecological era.

Along the route, there have been great changes in farming practices, markets, and farm policies. The impacts upon families, communities, and the environment have been dramatic.

Most agricultural changes evolve gradually. During certain periods, however, wars, depressions, scientific discoveries, and international developments have given rise to rapid change. Today a rich diversity of practices, enterprises, and values comprise the entire spectrum of American agriculture, as the old and the new are combined.

This issue of *Illinois Research* features many of the ideas, practices, and philosophies emerging in agriculture. Sustainable agriculture is difficult to define. Perhaps it can be understood most easily by examining specific technologies and practices that can be seen, measured, and evaluated. This issue describes several of these more tangible components. Sustainable agriculture can be understood, also, in terms of an overarching philosophy, which likewise emerges in the articles by University of Illinois researchers and educators.

The value of devoting an entire issue of *Illinois Research* to sustainable agriculture is in calling attention to the tip of an iceberg best described as an ecological and environmental perspective now beginning to permeate production agriculture, its related businesses, and its research and education enterprises. This perspective is tempering but not displacing the forces of competition, profitability, and production in agriculture and introducing a sensitivity to the human relationship with the land and all living things. It is alerting us to ethical issues in agriculture, relating agriculture to the larger society, and defining our concepts of responsibility to humans and nature.

The articles in this issue are indicative of the interests and capabilities of many University of Illinois College of Agriculture researchers and educators who are dedicated to an environmentally sound, sustainable, and productive agriculture.

Harvey J. Schweitzer, professor emeritus of agricultural economics and former assistant director, Agricultural Experiment Station

A field at the Orr Agricultural Research and Demonstration Center.

Can Sustainable Agriculture Sustain the Farm Family?

John C. van Es and Robert J. Reber

In the 1987 Census of Agriculture, Illinois had 88,786 farms, about 150,000 fewer than in 1920. One main reason for this change was that a technology dependent on fossil fuels had been substituted for labor on the farm.

The continual introduction of technology has resulted in both an increasing production and a persistent squeezing of the profit margins of individual farmers. To attain a standard of living comparable to that of nonfarming citizens, many farmers joined a rapidly growing urban labor force, or at least encouraged their children to do so. Those remaining on the farm pursued a strategy of growth, increased use of technology, and greater production in a relentless struggle to survive in a world of small profit margins.

Changes

The consequences of the changing farm structure for farm families and rural communities are well known. Farm families frequently found themselves under great stress as they tried to adjust to economic forces beyond their control. Although certainly not all departures from farms were associated with extreme hardships, enough cases have been documented in research studies, literature, and films to etch a picture of the American farm family as caught in a losing battle to save its way of life.

Many rural communities, too, have suffered the consequences of the agricultural transformation. The loss of farms made it difficult to maintain businesses serving agriculture; fewer residents led to closing or consolidating rural schools, hospitals, and churches. People remaining in the rural community often found (and continue to find) it impossible to satisfy their economic, social, and cultural needs locally.

For those remaining on farms, life has frequently been stressful. The normal insecurities of farm life, such as weather and crop disease, have been intensified by worldwide economic developments. For example, untimely rainfall in Brazil or the size of the federal deficit influences the year-end profit statement. Finally, health and safety concerns and environmental problems associated with modern farm technology and practices are forcing farm operators to confront very difficult choices from limited options.

Much of the current effort to create a more sustainable agricultural system has its basis in attempts to deal with the health and safety concerns, environmental degradation, and economic failures associated with modern farming practices. Yet, the changes in agriculture go far beyond these issues, to include the decline in the number of farms and the decline of rural communities, especially those that are agriculturally based. Until now, the attempts to create a sustainable agriculture have paid too little attention to how this approach might affect the individual farm unit's sustainability or the viability of the agriculturally based community. The following section touches on some of the social aspects of sustainable agriculture: (1) the family decision-making issues and (2) the relationship between the sustainability of the individual farm unit and the rural community.

Decision Making

On the family farm, both husband and wife are actively involved in decisions to keep the farm economically productive, and in decisions about teaching and rearing the children. The discussions on sustainable agriculture emphasize the interconnectedness of the different parts of the biological, economic, and physical system. These discussions, however, rarely go beyond the treatment of the farm as a production unit dominated by the (typically, male) farm operator.

But, according to research, both spouses traditionally have had their own spheres of responsibility and authority, which together constitute the family farm. For example, the male makes most decisions about routine purchases of farm supplies, is responsible for most field and animal work, and supervises hired help. The female typically takes major responsibility for the family's well-being, including nurturing and rearing the children. Additionally, she may do some or all of the farm record keeping. However, husband and wife may jointly decide major farm changes, such as borrowing money for buying land or switching from a specialized grain operation to a more diverse farm management scheme that introduces complex rotations among various crops and livestock enterprises.

The farm wife's traditional responsibility for health and safety issues and her participation in decisions about major

changes in farm enterprise activities make it likely that women will play a significant role in the transition to a sustainable agricultural system. Yet, until now little was documented about women's influence on decisions to shift the farm operation to a more sustainable approach.

Income

Another way in which farm families are likely to play an important role for sustaining the individual farm unit relates to the families' ability to attract nonfarm resources to support the farm household. If sustainability is to include the continuation of many smaller and medium-sized farms — a goal often expressed by advocates of sustainable agriculture — any plan must include consideration about sources of off-farm income that some units may require.

Unless significantly higher profit margins are maintained, which is not likely in a world economy, operators of smaller enterprises will find it difficult to support adequate living standards. Sustainable agriculture as envisioned by some will not likely change that situation. Under these economic conditions, a system that sustains individual units may depend on the community's providing off-farm employment for members of the farm household. Without such support, the survival rates of smaller units may not improve.

The dependence of the farm household on off-farm income also indicates that any system of sustainable agriculture must accommodate the farm labor demands on the household to meet off-farm income needs. Whether it is the wife, the husband, or both who take an off-farm job is probably not important as long as the household can meet the labor demands both on and off the farm. Because many proposed systems of sustainable agriculture appear to be more labor intensive than conventional systems, accommodating labor demands may become a significant issue.

Benefits

Although individual farms may still depend on off-farm income, the widespread adoption of a sustainable system will provide benefits to the local community, as will the decrease in environmental degradation. The increased variety of agricultural practices in a sustainable system should insulate the individual farm and the local community from the large economic swings that often accompany a highly specialized system.

Increased agricultural diversification and greater attention to conservation practices such as the use of cover crops and shelter belt plantings could generate additional benefits to the community: for example, a more pleasing countryside aesthetic and an increased biodiversity of both game and nongame species.

Making agriculture sustainable environmentally and economically does not necessarily imply that individual farms will more likely survive in a competitive market environment. If maintaining many farms is a desired outcome of a shift to sustainable agriculture, planners must be more cognizant of the social basis of sustainable agriculture. Developing supportive relationships between the farm enterprise, the farm household, and community resources will be necessary if sustainable agriculture is to include sustainable family farms.

John C. van Es, professor of rural sociology, Department of Agricultural Economics, and Robert J. Reber, associate professor of nutrition, Division of Foods and Nutrition, School of Human Resources and Family Studies

Economic Incentives for Alternative Cropping Systems

Earl R. Swanson and Loyd M. Wax

Economic incentives play a major role in a producer's decisions to adopt a cropping system. In this article we view economic incentives in terms of (a) average net returns over a period of years and (b) riskiness, or the year-to-year variation in net returns. A cropping system is a combination of a crop rotation, tillage practice, and level of pesticide use. Eighteen alternative cropping systems were evaluated. Without a precise operational definition of "sustainable," it is not possible to rank all 18 systems in terms of their "sustainability." Some instructive comparisons can be made, however, that indicate the strength of economic incentives in moving toward adoption of more sustainable cropping systems.

A Six-Year Experiment

A six-year cropping system experiment was conducted from 1980 to 1985 at three Illinois locations: DeKalb, Urbana, and Dixon Springs. The results of this experiment were used for our economic evaluation of cropping systems, providing a much better basis for evaluation than two other approaches commonly used.

One approach falls short because the experience of a few individual farmers using certain practices that appear to be successful may not be valid for transfer to other farmers. Even if the physical environments are similar, differences in management skills may prevent successful repetition on other farms. Another approach to economic evaluation involves the informal synthesis of results from various single-practice systems.

For example, the effect of the tillage system on crop yields is difficult to determine without knowing the crop rotation and the level of pesticide use. In short, we are dealing with an interdependent system of rotation, tillage system, and level of pesticide use. To evaluate that system's technical and economic performance, we must know something about the interactions among its components. The six-year cropping system experiment is designed to reflect this interdependence and thus provides a more reliable base for assessing effects on crop yields and, in turn, economic results.

Cropping System Components

The results of the cropping system experiment at Urbana will serve to illustrate economic evaluation of alternative cropping systems. Three crop rotations were considered: (CC) continuous corn, (CS) corn-soybean, and (SS) continuous soybean.

Two tillage systems were used: conventional tillage (CT) and reduced tillage (RT). The conventional tillage of any crop following corn involved either stalk chopping or mowing, disking and moldboard plowing in the fall, and at least two passes with a secondary tool in the spring. Following a soybean crop, conventional tillage plots were chisel plowed in the spring and received at least two passes with a secondary tillage implement. Reduced tillage following soybeans did not include any tillage in the fall but usually involved at least two passes with a secondary tillage tool in the spring. Reduced tillage following corn involved no fall tillage but at least two spring tillage passes of either a disk or field cultivator. All plots were cultivated at least once.

The three levels of pesticide use — low (LP), medium (MP), and high (HP) — were differentiated by the use of various combinations of herbicides and insecticides. LP used one or two herbicides. MP used two to four herbicides and a soil insecticide for corn. HP used three to six herbicides and doubled the MP rate of the soil insecticide.

Preplant herbicides were applied and incorporated just prior to planting, by two passes with a tandem disk set to cut to a depth of four to six inches. Preemergence herbicides were applied just after planting, with no incorporation. Early preplant herbicides were applied three weeks before planting. Postemergence herbicides were applied in most instances when weeds were three to four inches tall. All herbicide treatments were broadcast applications. Soil insecticide treatments were applied at planting.

Within each level of pesticide use, treatment amounts (rates and number of applications) varied yearly as dictated by the recent past history of pest control. Total usage and cost, however, were held relatively constant.

Effects upon Crop Yield

The experimental design makes it possible to estimate the separate influences of crop rotation, tillage system, and level of pesticide use on the per-acre yields of corn and soybeans. Figure 1 shows the

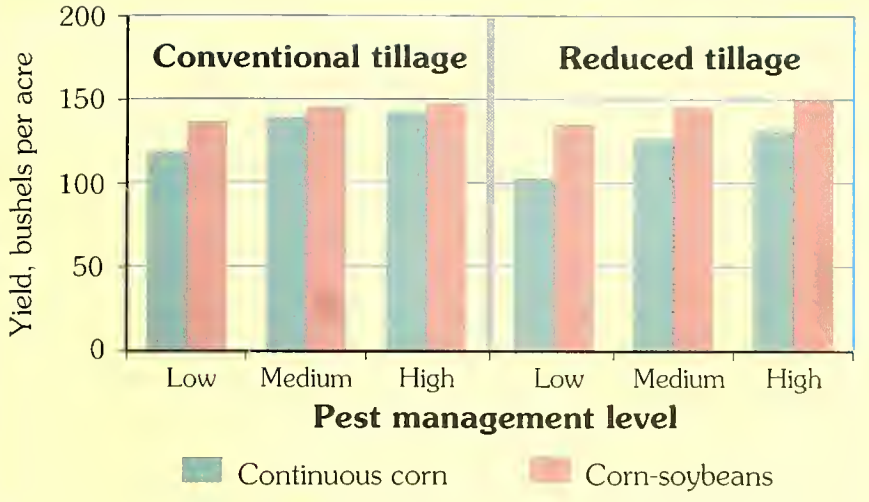


Figure 1. The effect of rotation on corn yield, Urbana, 1980 to 1985.

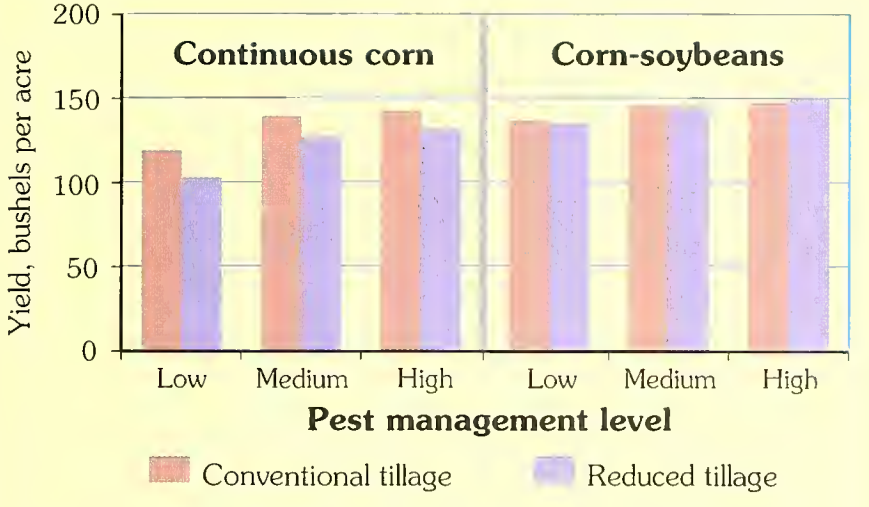


Figure 2. The effect of tillage on corn yield, Urbana, 1980 to 1985.

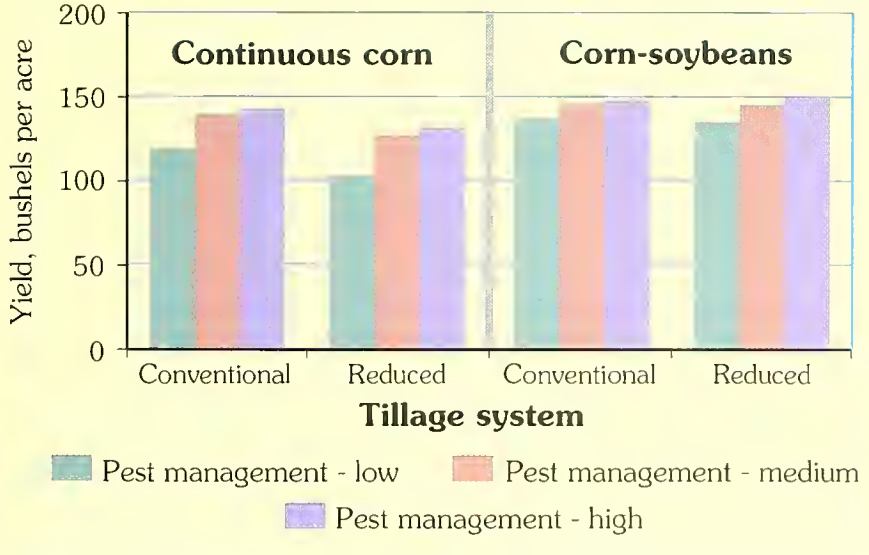


Figure 3. The effect of pest management on corn yield, Urbana, 1980 to 1985.

six-year average yields at Urbana for the two rotations of corn. Note the higher per-acre corn yields under a rotation for all levels of pesticide use with both conventional and reduced tillage. (Soybean yields displayed a similar result.)

Figure 2 shows the effects of tillage on corn yields. Under continuous corn, reduced tillage results in decreased corn yield. Yield differences between tillage methods are mixed and smaller with the corn-soybean rotation than with continuous corn.

Figure 3 shows the response of corn yields to the level of pesticide use. The yield increment from increasing the level of pesticide use from low (LP) to medium (MP) is much higher with continuous corn than with the corn-soybean rotation.

Net Returns and Risk

One reason for variation in crop yields among cropping systems is the difference in type and amount of nonland inputs. To account for these differences, costs per rotation acre were calculated and subtracted from the value of production. Average prices and costs for the six-year period were used to calculate net returns. Corn was valued at $2.50 per bushel, soybeans at $5.97. Land costs were not included because these costs are the same for each cropping system.

In Figure 4, we note a group of eight cropping systems with the highest net returns, between $117 and $133 per acre: CS-RT-MP, $133; CS-CT-LP, $127; CS-RT-HP, $129; CS-RT-LP, $119; CS-CT-MP, $129; CS-CT-HP, $118; SS-CT-HP, $127; SS-RT-HP, $117.

Six of these eight cropping systems use a corn-soybean rotation. The two continuous soybean systems achieve their high return in part due to the high level of pesticide use.

This cluster of eight cropping systems not only has high net returns but also has greater income stability than most of the other systems. The standard deviation of net returns (horizontal axis of Figure 4) is used to measure the variation in net returns. Because six-year average corn

and soybean prices were used to value crop production, only yield variability is reflected in this measure of net returns variation. The income stability in these systems is primarily due to the corn-soybean rotation. Corn and soybean yields are not perfectly correlated.

In Figure 4, the six systems with medium return and medium risk and the four systems with low return and high risk are all continuous cropping of either corn or soybeans. The four systems in the lower right-hand corner (low return-high risk) all have a low level of pesticide use.

Implications for Sustainable Agriculture

The economic evaluation presented in the preceding paragraphs is based on two criteria — average net returns per acre and the year-to-year variation in net returns per acre. How do these cropping systems rank in terms of their sustainability? In general, the reduction in soil loss that would occur in a shift from conventional tillage to reduced tillage represents a movement toward a sustainable system. Further, a decrease in the level of pesticide use might also contribute to achieving a sustainable system. From the standpoint of sustainability, it would be desirable to adopt CS-RT-LP: a corn-soybean rotation with reduced tillage and low pesticide use.

Given the uncertainties in agricultural production, one could hardly argue there is much difference in economic incentives among the eight cropping systems in the high return-low risk group. Thus, a shift to CS-RT-LP would occur for reasons other than economic ones.

One reason for the rather narrow economic differences among the eight best-performing cropping systems is the rather limited range of practices used in this experiment. For example, even the low level of pesticide use employed some herbicides. Corn and soybeans were the only crops considered; legume forage crops, for example, were not an option. Nitrogen fertilizer applications to corn were kept uniform in this experiment. Indeed, it may be premature to evaluate alternative cropping systems in terms of both economic incentives *and* sustainability until a broader range of alternative rotations, tillage systems, and pest management systems have been included in a similar six-year experiment.

Earl R. Swanson, professor emeritus of agricultural economics, and Loyd M. Wax, USDA agronomist and professor of agronomy

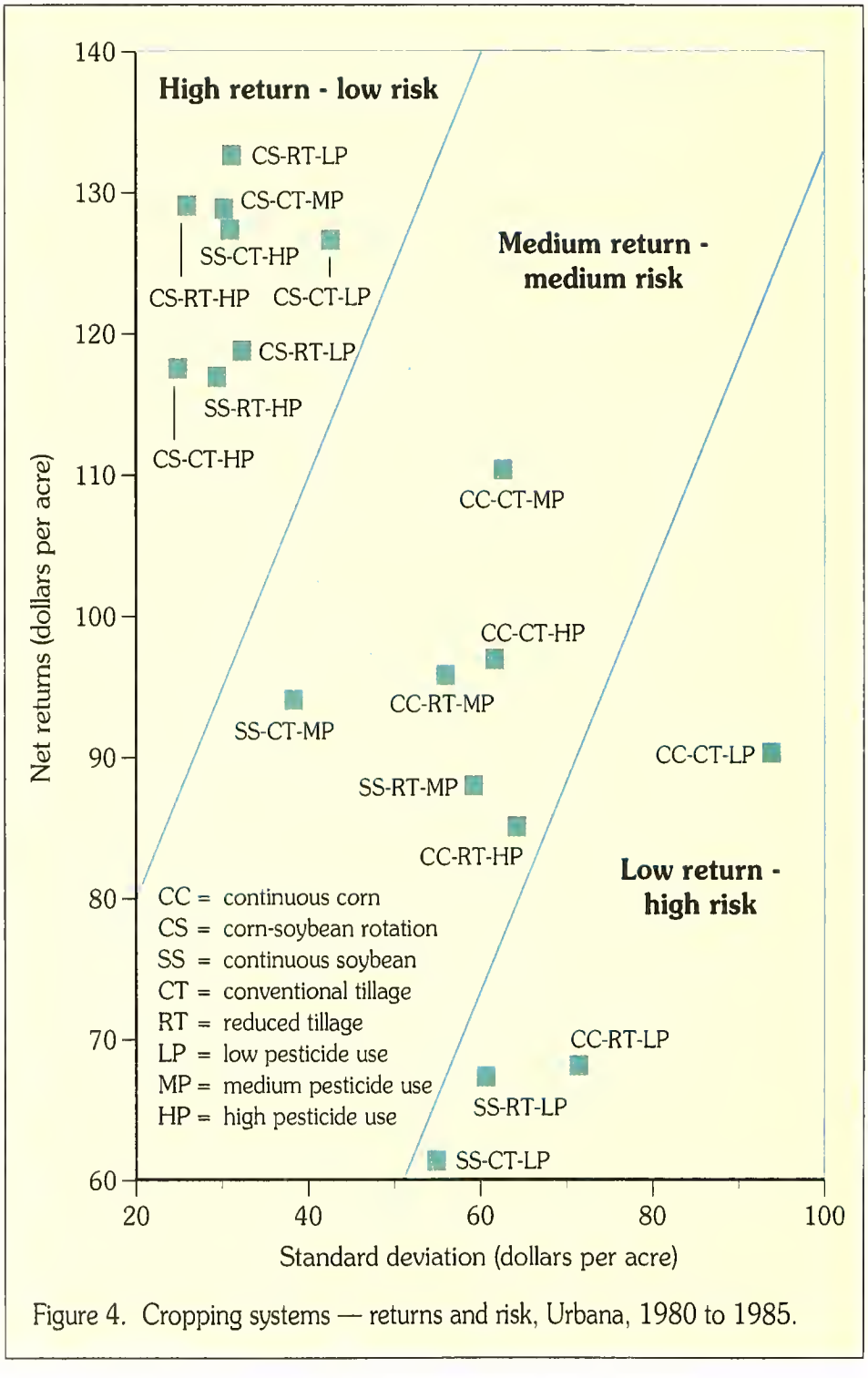


Figure 4. Cropping systems — returns and risk, Urbana, 1980 to 1985.

Policy Dimensions

Harold D. Guither

For every policy decision, there is a consequence. A policy to encourage and promote low-input sustainable agriculture (LISA) has consequences for producers, for consumers, and for agricultural business firms supplying farmers and marketing agricultural commodities. The nature and the extent of these consequences, in many cases, have yet to be determined.

Defining and understanding sustainable agriculture. To anticipate how sustainable agriculture policies can affect Illinois farms and rural communities requires that we understand exactly what sustainable agriculture is and what it is not.

A survey of Illinois agribusiness firms in the spring of 1989 revealed that only 32 percent believed they understood what LISA is, 32 percent believed that efforts to conserve resources and maintain profitable farm enterprises are a major focus, and only 10 percent believed that it would be beneficial to their business if most farmers followed the LISA program. The responses showed much uncertainty about what LISA is and how it can affect their business.

Crucial questions. The consequences of LISA will depend upon the nature of government programs and actions taken to implement a system of using fewer cash inputs in the production process. Programs that force abrupt changes in using fertilizers, pesticides, and animal health products can have immediate negative impacts upon farm production, farm incomes, and the quality of farm products, although environmental conditions may improve. Programs designed to make changes over a period of years may have little noticeable effect on total farm production, farm incomes, and the quality of farm products moving to market.

Will chemicals and fertilizers be more stringently regulated? The immediate prohibition of many popular and effective pesticides generally accepted by the most progressive producers would be disastrous. However, reducing the use of fertilizers and chemicals beyond the amounts needed for effective pest control or optimal yields could benefit producers, consumers, and the environment.

Will restrictions be mandatory or voluntary? Through the years, Illinois farmers have accepted voluntary price support and production control programs more readily than mandatory programs. Similar reactions may be expected to other proposed programs.

Farmers accept policies that they believe are in their best interest. In a policy preference survey among Illinois farmers in the spring of 1989, 63 percent believed that soil conservation and water quality compliance should be a condition for receiving farm program benefits. On another question, 62 percent agreed that the government should regulate certain farming practices and land uses to reduce pollution of underground and stream water.

What kinds of regulations will be involved? The most successful programs will offer incentives for voluntary compliance and minimal restrictions that disrupt profitable farming operations. An integrated crop management pilot program in five counties pays producers who voluntarily reduce pesticide use. The program's success, however, remains to be seen.

Harold D. Guither, professor of public policy, Department of Agricultural Economics

A farmer applies lime to his field.

Canola: An Alternative Crop for Illinois

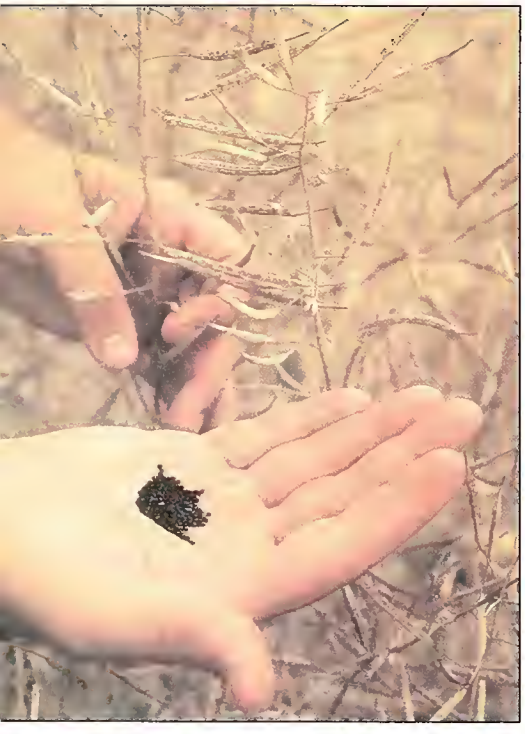
Emerson D. Nafziger and Robert W. Frank

Many strategies for creating a more sustainable agriculture include crop diversification. The number of crops grown on any one field in Illinois has decreased with the movement toward a more specialized agriculture; and attempts to broaden the cropping base with sunflowers, crambe, buckwheat, and other crops have not had wide success. To diversify cropping, Illinois farmers are now testing winter canola, oilseed rape genetically improved for oil and meal quality.

As an edible, oil-producing crop, canola will not always offer a clear marketing alternative to soybeans because its price will follow world oil prices. Because canola is harvested in June, however, price changes associated with the growing season for soybeans may be advantageous for canola. In the last two years, price changes have worked both to canola's favor and to its detriment. The price rose before harvest in 1988 because of the drought but fell in June 1989.

The agronomic diversity offered by canola is also somewhat limited. Although the crop is in the field for about the same period as winter wheat, it is necessary to plant three to four weeks before winter wheat, which may prevent canola from following corn or soybean harvest in most of the state. Set-aside acres or small grains work well as preceding crops. Fertility, soil, and general weather conditions that are favorable for canola are also favorable for wheat, however, and the very good wheat yields of 1989 made the wheat-canola comparison favorable to wheat. In some years the canola harvest will be a few days earlier than wheat, thus improving chances for a soybean doublecrop. Because the weather in 1989 was cool, canola and wheat were harvested about the same time, disappointing farmers expecting an early canola harvest.

Most canola varieties that seed companies sell to Illinois farmers were developed in Europe, where the crop is widely grown. Limited testing and experiences of Illinois farmers show that these varieties are fairly well suited to conditions here but will require high-yielding varieties with earlier maturity dates and improved resistance to seed shatter, disease, and lodging. Canola requires a fine seedbed and careful harvest but no special equipment. Improved weed control, however,



↑ Canola has small, round seeds that thresh easily from the pods.

Marketing Challenges and Risks of "Sustainable" Agriculture

Sarahelen R. Thompson and C. Christopher Doll

The effect on producer income of adopting low-input, or "sustainable," agricultural practices depends on how these practices affect yields, production costs, and price received per unit.

The adoption of low-input practices may result in reduced yields as compared to conventional methods. To compensate for reduced yields, producers must reduce production costs, receive a higher price per unit of output, or do both. Although "low-input" suggests lower production costs, total production costs may actually rise if more costly labor is required to replace chemical inputs. Therefore, the challenge for many producers who adopt low-input methods is to find a means of obtaining higher returns per unit of output and thus to avoid lower net returns from farming.

One way that producers may receive a higher price is by targeting production to consumers willing to pay a higher price for food produced with reduced chemical inputs. Among some consumers the growing concern about the potential health hazards to food or the environment from chemicals applied in farming makes them willing to pay higher prices for food grown "organically" or with reduced chemical inputs.

If producers hope to cash in on this market, they must tailor their production and marketing programs accordingly. They must also inform consumers of their product's availability by advertising and labeling.

is necessary: only two herbicides currently are labeled for use on canola in the United States. Seed loss during harvest can also cause canola to become a weed in most fields where it is grown.

Although prices for canola will not always be favorable, increased familiarity with the crop and further adaptive research should make it an acceptable alternative for Illinois farmers. Average yields of about 35 bushels per acre should increase as farmers gain more experience; however, farmers should keep acreage small initially to limit risk.

Emerson D. Nafziger, associate professor of agronomy, and Robert W. Frank, Extension adviser, agriculture, Jackson County

↑ Canola's bright yellow flowers are distinctive in the spring.

Unfortunately, reducing chemical inputs may reduce the product's quality, as conventionally judged. For example, fruits and vegetables produced with low-input methods may have a higher incidence of blemishes, some physical and some superficial.

If the reduction in product quality is only superficial, and does not diminish palatability, producers may still receive a reasonable return if they can induce consumers to try their product. Besides labeling such produce as "organically grown" or "pesticide free," clever marketing slogans may be used to overcome consumer resistance to blemished produce. One grower in southern Illinois has used the "kissed by nature" slogan to sell hail-damaged apples.

The marketing problem is more difficult when reduced chemical inputs significantly reduce product quality. For example, a reduction in pesticides may result in a product with more disease or insect damage. In this case, it is likely that growers will receive a much lower price or be unable to sell their output through regular markets.

Crop diversification and rotation are low-input production methods that are often suggested to spread and reduce overall risk, but these methods also result in some problems. To attract and keep customers, producers must provide steady supplies of certain crops. Producers can spread the risk of crop failure or low crop prices over several crops by producing more than one crop (diversification). To accommodate the production and rotation of a variety of crops, thereby reducing the producer's income risk and improving productivity, individual operations may have to grow in size. With each added crop, a producer's management ability in both the production and marketing areas must also increase.

Sarahelen R. Thompson, assistant professor of agricultural marketing, Department of Agricultural Economics, and C. Christopher Doll, area adviser, fruits and vegetables, Illinois Cooperative Extension Service

↓ Because canola pods often do not ripen uniformly, knowing when to harvest may not be easy.

Economic Study of Efficient Reduced Input Farms in Illinois

Robert H. Hornbaker

Rural America is experiencing far-reaching problems that affect society and producers. There are growing societal concerns over environmental quality. Chief among these concerns is groundwater contamination from agricultural pesticides, herbicides, and fertilizers; but also important are soil conservation, silting in lakes and streams, odors, and worker safety.

These concerns have led to increased interest in and adoption of production practices such as reduced tillage, no till, and organic farming that diminish the potential for environmental damage. These concerns have also prompted proposals to reduce or eliminate pesticides, herbicides, and fertilizers.

Despite recent government programs and relatively strong incomes for the agricultural sector in general, a significant number of farmers and landowners are in economic distress. For these producers to remain in the agricultural sector, they will need help in identifying production practices and mix of input strategies to enhance profits.

Some groups or individuals concerned with the environment may argue that any input with negative environmental effects not be used. Others advocating maximum production may suggest application of more than the average profit-maximizing amount "in case it's an above-average year." Neither policy may be sustainable in the long run, and the first policy may not even be sustainable in the short run.

Economic Theory

In static production theory, some known quantity and mix of inputs and combination of outputs will maximize profits for a given farm. But, because biological production processes are dynamic, farmers do not face static production decisions. These uncertainties make it impossible for farmers to apply the profit-maximizing level of inputs on all their fields. Profit-maximizing levels differ by location and fields due to soil quality and climate and with changes in commodity prices and input prices. Input applications both above and below the profit-maximizing levels can thus occur, leading to reduced profits.

Figure 1 demonstrates a case where quantities of input below (q_1) and above (q_2) the profit-maximizing amount yield lower profits (π_1). In the short run, a farmer may be indifferent to these two quantities because they provide the same level of profit. However, if negative externalities are associated with the input q, quantity q_1 should be used. By using quantity q_1, the amount of input $q_2 - q_1$ is not placed in the environment and profits are sustained at the same level as with q_2. Although the farmer would like to use the level of input that provides profits of π^*, the externalities associated with some chemical inputs such as nitrogen fertilizers, herbicides, and insecticides may dictate that it is better to, on average, apply input quantities below q_1 not above.

The dynamics of production entail not only applying the correct quantity of input, but also using the proper application, timing, and procedure. Technical

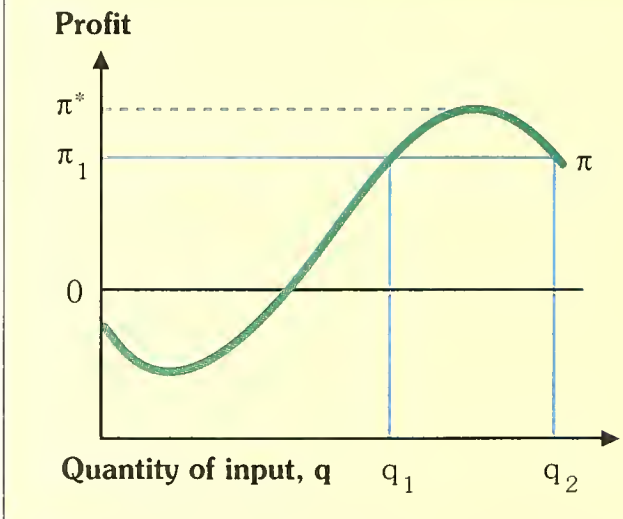


Figure 1. Profits associated with input quality.

efficiency is the management ability required to apply or implement the input quantity to achieve the maximum output for that level of input. Technical inefficiencies, at the firm level, quantify the technical management input that is not provided along with other inputs and imply that profits can be increased or input use can be decreased by improved management practices that increase production efficiency.

Empirical Analysis

The preliminary results of a study examining the economic feasibility and viability of reduced-input agriculture are presented. Using 11 years of detailed information from the Illinois Farm Business and Farm Management records, profitable reduced-input farm operations were identified. Based on their per-acre expenditures for cash inputs — fertilizers, herbicides and pesticides, seed, drying and storage of grain, fuel and oil, and hired labor — 161 farms were stratified. This analysis is based on expenditure levels rather than input quantities. Generally, there is little between-farm variation in the prices paid for most inputs. Thus, the categories of farms will be referred to as high use and low use, remembering that the levels are relative to the other farms in the sample.

Farms were divided into three groups: (1) the high-use group, the 40 farms that spent the most on cash inputs on average during the 11 years; (2) the low-use group, the 40 farms that spent the least; and (3) the remaining 81 farms that fell in the middle in terms of cash inputs. The average yearly values from this analysis are depicted in Figures 2, 3, and 4.

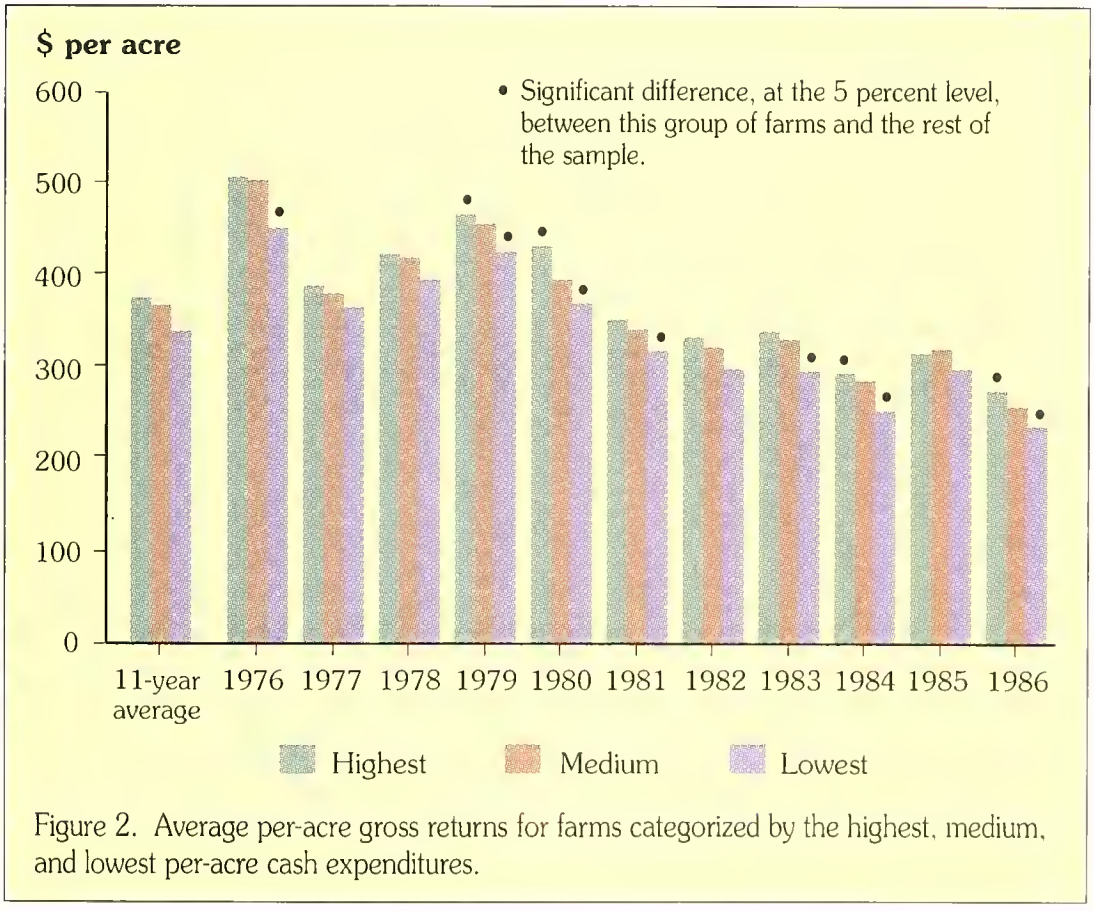


Figure 2. Average per-acre gross returns for farms categorized by the highest, medium, and lowest per-acre cash expenditures.

Farms in the study spending the highest amount on cash inputs harvested more bushels per acre, but their net income per acre was 17.5 percent less than that of farms that spent the least amount on these cash inputs. Adjusted for inflation, the high-use farms in the sample averaged $44 per acre (in 1982 dollars) for fertilizer and grossed $376 per acre. Farms that spent significantly less averaged $32 per acre and grossed only $339 per acre. The gross returns for the low-use farms were significantly lower, at the 5 percent level, in 7 of the 11 years. However, the net

profit for the low-use farms averaged $165 per acre compared to only $136 for the high-use farms over the 11 years. The high-use farms had significantly lower net farm returns at the 5 percent level in 8 of the 11 years.

As shown in Figure 4, the per-acre fertilizer expenses were significantly lower, at the 5 percent level, for the low-use farms in all years, as was the level of total cash expenditure.

These preliminary results tend to indicate that some central Illinois farms are more efficient than others, use fewer inputs, and show profits that are sustainable in the long run. Although new, improved tillage systems and crop rotations can reduce levels of input use, better management or increased technical efficiency associated with existing practices can also lead to reduced input use, sustained profits, and less damage to the environment.

Robert H. Hornbaker, assistant professor of farm management and production economics, Department of Agricultural Economics

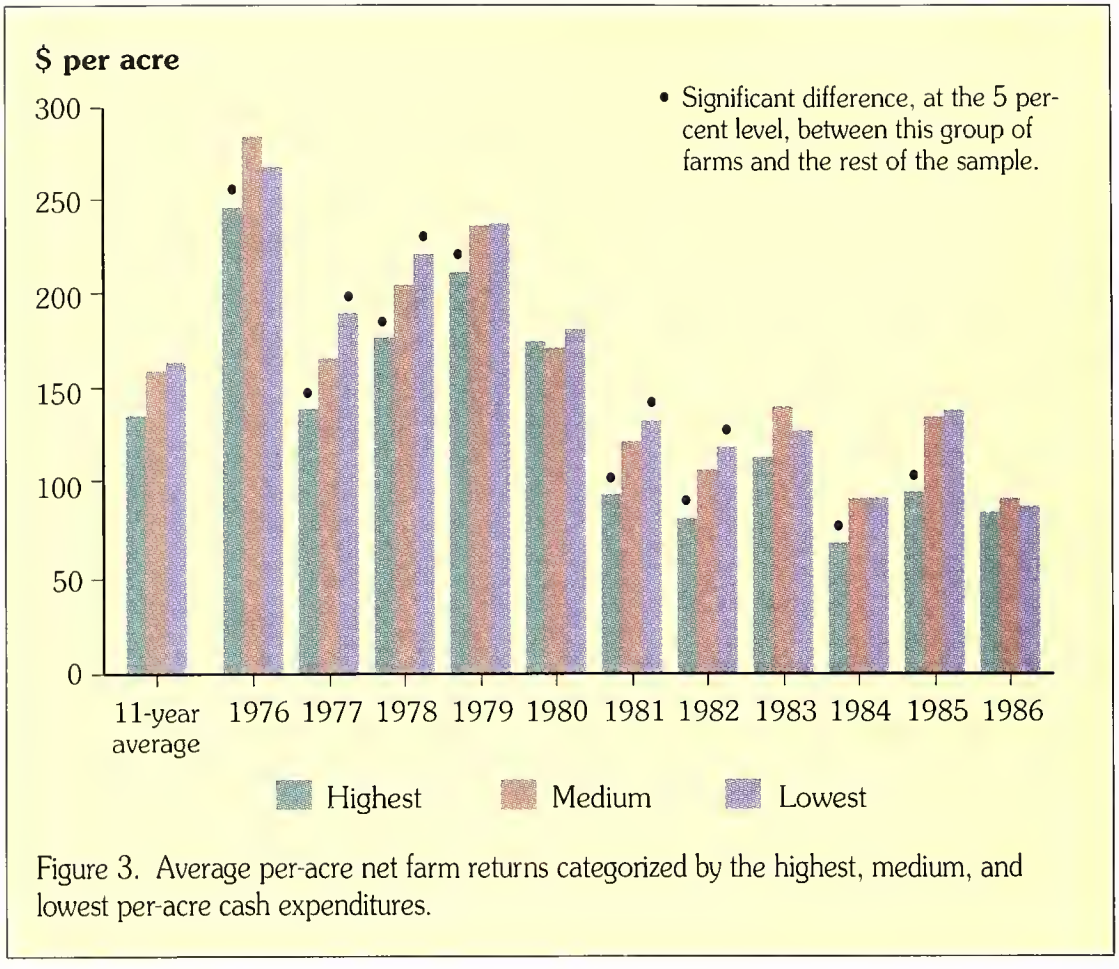


Figure 3. Average per-acre net farm returns categorized by the highest, medium, and lowest per-acre cash expenditures.

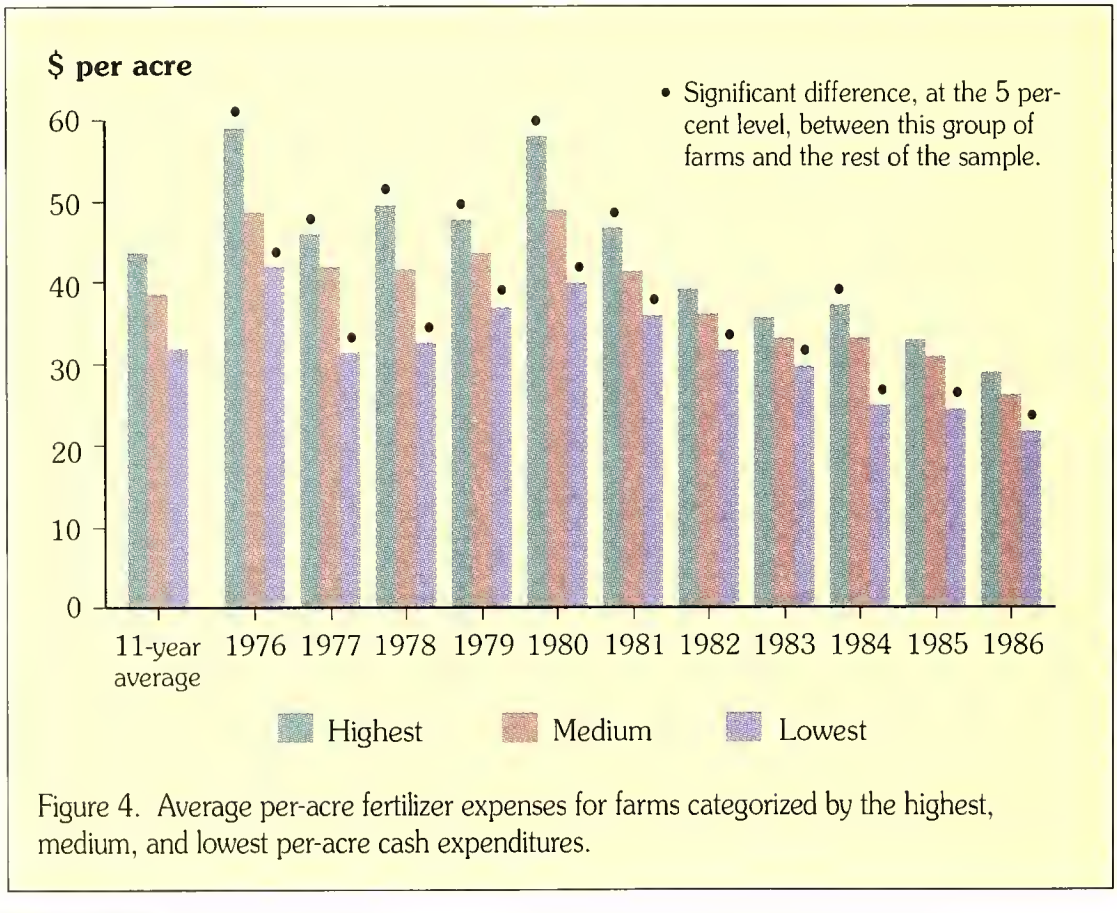


Figure 4. Average per-acre fertilizer expenses for farms categorized by the highest, medium, and lowest per-acre cash expenditures.

IPM: A Systems Approach to Sustainability

Donald. E. Kuhlman, Ellery L. Knake, Michael E. Gray, and H. Walker Kirby

Integrated Pest Management (IPM) began in Illinois in 1972 with 46 Boone County farmers in a pilot corn-pest scouting program initiated by the Cooperative Extension Service (CES) and the Natural History Survey. The next year the program expanded to include Hancock, Shelby, and Warren counties. During the 1970s, IPM's formative years, a primary objective was to demonstrate to farmers the value of scouting for insect, weed, and disease pests in field crops.

Too often IPM is equated with biological or nonchemical control, which farmers do not always readily accept. In a 1979 address to Congress, President Jimmy Carter described IPM as "a systems approach to reduce pest damage to tolerable levels through a variety of techniques including predators and parasites, genetically resistant hosts, natural environmental modifications, and, when necessary and appropriate, chemical pesticides." Basically, the IPM concept uses pest control actions that ensure favorable economic, ecological, and sociological consequences.

SA/LISA

Recently, the concepts of sustainable agriculture (SA) and low-input sustainable agriculture (LISA) have captured the attention of scientists, farmers, environmentalists, and others involved in agriculture. The definitions of SA and LISA vary, as does that of IPM; but all three concepts embrace cost-effective practices that conserve the soil and protect the environment and human health.

According to University of Illinois agronomists Robert G. Hoeft and Emerson D. Nafziger, SA is "a management system that uses inputs available on the farm and those purchased externally to obtain the highest productivity and profitability from a farming operation while minimizing adverse effects on the environment." Without question, nutrient cycling and pest management will be major components of such systems.

IPM/LISA: Revolution or Evolution?

Since 1973, IPM has attracted the support of farm organizations, politicians, environmental organizations, farmers, the pesticide industry, and agricultural colleges. But will they also support LISA, a concept that is now evolving?

As LISA and SA evolve, it is important to recall that in the 1970s the IPM concept was not well understood or accepted by some of these same groups. Many agriculturalists were suspicious of IPM. The pesticide industry feared that pesticide sales might plunge. Environmentalists viewed IPM as a system to eliminate or reduce pesticide use. University researchers and Extension staff, always cautious, saw a need for IPM but were sometimes reluctant to proceed without a large research base. The farmer was bewildered, perhaps even amused, by efforts of university staff to introduce new concepts for pest control: pest scouting, economic thresholds, biological control, and more judicious use of pesticides. A common belief in the early 1970s was that pest control with pesticides was working, and there was no need for change.

Objectives

University of Illinois scientists William H. Luckmann, Howard B. Petty, Robert L. Metcalf, and Stevenson Moore III were strong advocates of IPM in its early years. Despite the need for chemicals to control pests, the scientists sensed an urgency for farmers to adopt IPM systems due to pesticide-resistant pests, increasing costs of petroleum-based pesticides, environmental contamination, adverse effects on human health, and ecological disturbances — all consequences of the injudicious use of pesticides.

Today, concerns about groundwater quality, pesticide residues in food, and the health and safety of producers and consumers will likely increase even more. The public will expect leadership and vision in addressing these complex issues.

The components of IPM seem ideally suited for use in SA systems. IPM practices can minimize costs, risks, and total dependence on farm chemicals. During its evolution, LISA should build and expand on the IPM philosophy. Scientists and farmers will explore ways to reduce inputs and keep outputs and quality high without sacrificing income. The alternatives, however, must be practical, affordable, and adoptable. One objective that IPM and LISA share is to develop techniques that will allow farmers to reduce their costs and maintain their level

Table 1. Field Crop Pest Scouting Trends in Illinois; 1982, 1985, and 1988

	Corn			Soybeans			Alfalfa		
	'82	'85	'88	'82	'85	'88	'82	'85	'88
	percent of crop acres								
Scouted by IPM consultants	3	5	4	4	4	4	<1	<1	2
Scouted by farmer or family members	41	55	50	37	56	57	10	10	23
Total scouted	44	60	54	41	60	61	11	11	25

of profitability. Sustainability also implies protection of our soil and water resources to assure productivity and other benefits for society, such as a high-quality, stable supply of food and water.

IPM in Illinois

The IPM program has centered on the state's major crops: corn, soybeans, wheat, and alfalfa. In field-crop pest scouting, the most visible IPM activity, scouts monitor fields regularly; and control decisions are based on economic thresholds. During 1988, farmers or pest management consultants scouted 54 percent of the corn acreage, 61 percent of the soybean acreage, and 25 percent of the alfalfa acreage (Table 1). By the year 2000, virtually all crop acres will be scouted.

Pest management consulting, including scouts who charge for their services, is a relatively new enterprise in Illinois that began in the public sector. This practice is now being adopted by the private sector. In 1988, about 50 IPM firms employed 70 full-time staff and 250 seasonal employees to serve more than 1,500 Illinois growers.

Weed Control, LISA, and the Changing Landscape

During the past three decades, the availability and use of herbicides in Illinois have increased dramatically. In 1960, soil-applied herbicides, used on an estimated 5 percent of the corn and soybean acres, were applied primarily in a band at a cost of $2 to $5 per acre. In 1988, herbicides were applied to nearly all corn and soybean acres (Table 2). Most of these herbicides were broadcast — combinations and multiple applications being quite common — at a cost of $10 to $25 per acre. Since herbicides have given such dramatic, economical, and convenient weed control, farmers are not likely to stop using them in the near future.

Tillage. Illinois farmers are changing their practices. Chisel plows have gradually replaced many moldboard plows. More producers are interested in further tillage reduction to conserve fossil fuels, soil, water, time, and equipment costs.

It is said that no-till increases costs and requires more herbicides, but this is not necessarily true. Excellent weed control and corn yields higher than 200 bushels per acre have been obtained using little or no tillage for corn after soybeans, with essentially the same herbicides and rates as those for conventional tillage. With no significant benefit from midseason cultivation, a spray-plant-harvest program has very low inputs. If most Illinois farmers adopted this practice, we would take a great stride toward meeting conservation goals for the state while reducing inputs and helping to assure sustainability.

Ridge-till is another practice that can allow reduced herbicide costs by using band applications over the row and cultivating between the rows.

Rotations. University of Illinois research confirms that farmers moving toward *reduced tillage* rotations are on the right track. Illinois farmers have rotated crops for years, often simply by alternating corn and soybeans. Perhaps without realizing it, they have also rotated herbicides, using different ones for corn and soybeans, thus helping prevent resistant weed species from developing.

Cover crops. Scientists are exploring opportunities to take advantage of the mulching and allelopathic effects of cover crops for weed control. (Allelopathy is the process by which one plant releases chemicals or phytotoxins that inhibit the growth or development of another plant

Table 2. Illinois Corn and Soybeans Treated with Herbicides and Insecticides, 1969 to 1988

	Corn			Soybeans	
	Soil Insecticides	Post-emergence Insecticides	Herbicides	Post-emergence Insecticides	Herbicides
	percent				
'69	70	2	84	1	70
'72	60	3	86	6	83
'76	56	2	95	4	96
'78	65	7	98	1	98
'82	53	1	99	5	99
'85	42	6	99	1	97
'88	32	6	97	45*	96

* Severe outbreak of twospotted spider mites during drought.

growing nearby.) Because more farmers are realizing the folly of letting weeds multiply on set-aside acres, they are using clover or alfalfa as cover crops.

With modest use of herbicides, well-established cover crops such as alfalfa or clover can provide excellent weed control and lower inputs. Inputs are also reduced for no-till corn in legume sod used for set-aside or hay or pasture. A combination of 2,4-D and Banvel can provide early control of alfalfa at low cost. Triazines can control shallow-rooted clover without increasing rates or costs. Taking advantage of the nitrogen from legumes can also reduce inputs.

IPM, LISA, and Plant Pathology

Plant pathologists have long relied upon IPM and LISA. Most disease control programs are based on crop rotation, tillage, and proper planting time. Pesticide applications are primarily restricted to areas where severe disease outbreaks are damaging crops or to protecting high-value crops from pathogens.

IPM is a complementary component of low-input systems, particularly for disease management strategies. Scouting assesses plant disease problems, permitting a more judicious use of inputs that can affect not only the agroecosystem but also the producer's economic returns. Without relying on pesticides, producers can minimize the impact of pathogens by careful selection of seed sources, plant varieties, and tillage and rotation systems based upon scouting and monitoring.

Plant pathology has a history of using low inputs as primary disease control measures. Developing disease-resistant hybrids and cultivars has provided producers with a nonpolluting tool for reducing losses to common plant pathogens, such as leaf blights, root rots, fruit spots, stem diseases, and other destructive problems, at virtually no cost. Crop rotation is another tool that fits into both IPM and LISA as a powerful means to reduce the survival rate of plant pathogens. Nematode, bacterial, fungal, and viral populations all are reduced when suitable host crops are not present. Often, a single season of rotation between crops such as corn and soybeans will reduce pathogens below an economically damaging level. Because both crops fit well into most farming systems in Illinois, rotations are an excellent way to use a pest reduction component that adds very little to the cost of production inputs and offers a superior method of sustaining agricultural production when compared to a continuous crop with the added risks from pests.

Pathogen populations are also affected by other techniques, such as

- *Avoiding pathogens by excluding them from a geographic area:* programs that certify disease-free seed or monitor the movement of plant materials.
- *Eradicating pathogens through scouting and destruction of infected materials:* tillage programs that favor rapid decomposition of plant residues.
- *Protecting plants by modifying the growing environment to favor plant*

↑ John Sawyer checks corn plants at the Brownstown Agronomy Research Center.

↓ Mike Mainz uses a trap to determine insect populations at the Northwestern Illinois Agricultural Research and Demonstration Center, Monmouth.

growth, not pathogen development: row spacing, balanced fertility, and proper planting time.

These techniques depend upon recognizing the presence of pathogens and using long-term approaches rather than applying high-input or expensive, short-term measures.

Insect Pest Management in Corn

Effect of rotation. Corn and soybean agroecosystems are susceptible to large fluctuations in insect populations because they contain far less plant and animal diversity than a natural ecosystem. Attempts to manage pests with insecticides in these unstable environments can sometimes produce side effects. An IPM approach reduces insect pests to noneconomic levels without the side effects.

A corn-soybean-corn-soybean rotation, simple as it may seem, is tremendously effective in preventing corn rootworm damage to corn. In Illinois, about two-thirds of all corn is grown in rotation with soybeans (Table 3).

Surveys of 890 fields in 30 counties in the northern half of Illinois from 1986 to 1988 indicated the probability of economic damage from rootworms in corn after soybeans was about 1 in 90 fields (Table 4). Recognizing that crop rotation can prevent rootworm damage, Illinois farmers treated only 13 to 14 percent of the corn following soybeans with a soil insecticide in 1985 and 1988 (Table 3).

The low incidence of rootworm damage in corn after soybeans has permitted farmers to use scouting and rescue treatments for sporadic cutworm pests rather than always applying a soil insecticide. In general, the yield benefits from using a soil insecticide in corn after soybeans are negligible (Table 5); and by not using a soil insecticide, growers saved $10 to $14 per acre and avoided potential adverse environmental effects.

Table 4. A Survey of Corn Rootworm Damage in Corn after Soybeans, Illinois, 1986 to 1988*

Region	Number of fields with economic damage
Northwest	0 in 140
Northeast	3 in 210
West	0 in 120
Central	4 in 210
West	4 in 210
Total	11 in 890

* Surveys were conducted in 30 counties each year, 1986–1988.

Fields with economic damage on average have plants with several roots eaten to within $1^1/_2$ inches of the stem.

Black cutworm vigil. The moths migrate into Illinois in the spring on storm fronts from the Gulf Coast states, making it hard to predict where moths will lay eggs. Because black cutworms have the potential to cause serious problems each year in Illinois, more than 200 cooperating farmers throughout the state monitor the use of cutworm pheromone traps. (Pheromones are chemical substances released by insects to attract others of the same species. Some pheromones are chemically produced for use in insect traps.) By monitoring the traps, one can assess the abundance of cutworm moths, predict when cutting will start, and target the regions in Illinois where scouting is most needed.

This wait-and-watch approach, which has operated for nine years in Illinois, illustrates how IPM has reduced the use of soil insecticides on corn in Illinois from 70 percent of the acres treated in 1969 to only 32 percent in 1988 (Table 2).

Donald E. Kuhlman, program leader for environmental issues; Ellery L. Knake, professor of weed science; Michael E. Gray, assistant professor of agricultural entomology; and H. Walker Kirby, associate professor of plant pathology

Table 3. Cropping Sequences on Illinois Farms, 1985 and 1988

	Total acres		Acres treated with soil insecticides	
Rotation	1985	1988	1985	1988
	percent			
Corn after corn	34	26	97	83
Corn after beans	60	66	13	14
Corn after other crops	6	8	3	10

Table 5. Effect of Soil Insecticides on Yields in Fields of Corn after Soybeans, 1982*

Soil insecticide	Average yield, No. 2 corn
	bushels per acre
Amaze 20G	165
Dyfonate 20G	164
Furadan 15G	168
Lorsban 15G	166
Untreated	167

* Average of seven fields in Champaign, Christian, Lee, Morgan, Ogle, Piatt, and Sangamon counties.

Conservation Tillage and Sustainable Agriculture

John C. Siemens

↑ Ridge-till planted corn after cultivation.

Can conservation tillage and sustainable agriculture be compatible? It has been speculated that adoption of conservation tillage will lead to large increases in pesticide use. A primary objective of sustainable agriculture, however, is to reduce on-farm inputs including the use of herbicides for weed control.

Conservation tillage may be defined as any tillage system that leaves at least 30 percent of the soil surface covered with plant residue after planting. This residue can very effectively reduce soil erosion.

Adhering to this definition, conservation tillage will vary with the previous crop. After corn, tillage operations may include chisel plowing or disking, followed by a limited amount of spring tillage for seedbed preparation and incorporation of herbicides, or no-till could be used.

After soybeans, conservation tillage usually means no-till. Almost any tillage operation used would cover too high a percentage of soybean residue to be called conservation tillage.

Reduced soil erosion. Conservation tillage systems have been developed primarily to reduce soil erosion. Modern herbicides have facilitated the development and adoption of conservation tillage, resulting in speculation that widespread adoption of conservation tillage would increase pesticide use. Although pest problems are sometimes different and pesticide use patterns often change, adoption of conservation tillage has not led to large increases in pesticide use.

Because conservation tillage significantly reduces soil erosion and water runoff, it ensues that conservation tillage can also reduce contamination of surface water and areas adjacent to treated fields by reducing runoff of pesticides absorbed by sediment and dissolved in runoff water. Thus, the net effect of adopting conservation tillage should be fewer contamination problems.

Although no-till depends on herbicides for weed control, it allows farmers to reduce significantly their machinery inventory and use (reduced on-farm inputs). Ridge-till, however, may be the conservation tillage system least dependent on herbicides.

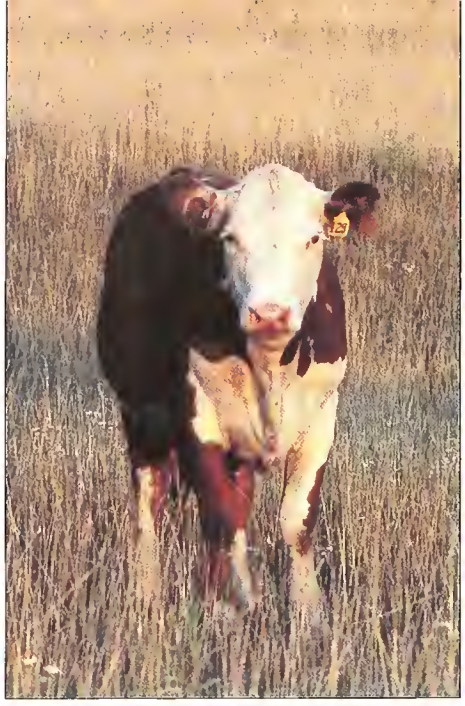
Ridge-tilling. A ridge-till system has many advantages. Weeds in the row are controlled at planting by a sweep attachment on the planter. Weeds between the rows are controlled by timely cultivation. With early planting, herbicide use is limited to application of a 12- to 14-inch band over the row. A broadcast herbicide application may be necessary if weeds emerge before planting. Other advantageous features are low machinery requirements and costs, generally good crop yields, and thus excellent profit potential.

A major disadvantage of ridge-till is that the system is somewhat limited to row crops. Small grains, narrow row soybeans, and forages do not fit well into this system, because it is impossible to form ridges in the narrow rows in which they are planted.

Sustainable agriculture promotes livestock grazing and crop rotations other than just corn and soybeans to minimize the need for off-farm inputs. Widespread integration of forages, wheat, oats, and livestock with the main crops of corn and soybeans would be a major change.

Soil erosion could be significantly reduced, especially if the soybean acreage were reduced. Production of winter wheat or alfalfa results in much less erosion than do corn or soybeans. Winter wheat and forages are commonly grown with less herbicides than row crops. Overall herbicide use could be decreased substantially with more crops, crop rotations, and livestock. However, it will be difficult to reduce both tillage and herbicide use, especially with continuous row cropping.

John C. Siemens, professor of agricultural engineering



Humans with health-conscious spouses are not the only ones who may be surprised to see high-fiber supplements added to their diets. If processing costs can be kept down, more high-fiber feedstuffs may find their way into the diets of livestock as well.

Improving High-Fiber Diets of Livestock

George C. Fahey, Jr.

Very large amounts of crop residues and other high-fiber feedstuffs with a low nutritive value are available on an annual basis. One rather conservative estimate is that the total farm crop residue supply in the United States is 500 million tons per year. Eighty percent of that total is corn stover, wheat straw, and soybean residue — materials common to Illinois.

Processing required. Processing usually is necessary to release the energy trapped in crop residues. Treatment, however, should not cost more than the value of the endproduct. Processed feeds should be more acceptable to the animal, resulting in improved feed intake. Processed feeds should be digestible at a higher rate, to a greater extent, or both, and thus improve nutrient availability.

Finally, it is important that the animal producer recognize that manipulating the usual protein and energy supplementation regimen may be necessary to achieve an economic return on the processing investment.

Chemical treatment is one method of upgrading fiber quality. Chemicals available for use include hydrolytic agents (hydroxides, ammonia, and urea), oxidizing agents (ozone, chlorite, sulfur dioxide, and hydrogen peroxide), and chemical mixtures (hydroxides and alkaline hydrogen peroxide).

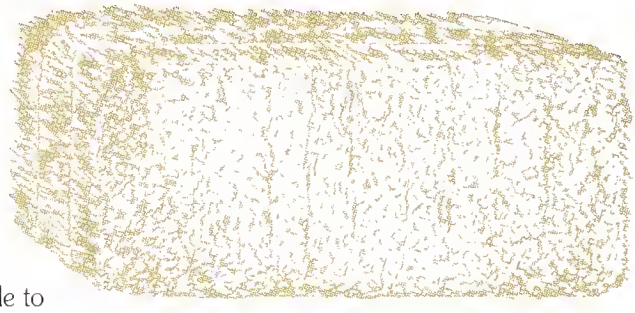
Hydrolytic agents hydrolyze certain chemical linkages in the plant cell wall; they also swell and disrupt fiber structure. Oxidants partially degrade lignin, a normal plant constituent and perhaps the most refractory natural organic compound in nature. A chemical mixture of a hydrolytic agent and an oxidant could provide the most efficacious chemical treatment possible.

The right stuff. When we began testing alkaline hydrogen peroxide, we sprayed a mixture of 5 percent sodium hydroxide and 2 percent hydrogen peroxide on low-quality fibrous feedstuffs. Results indicated that the treatment is an efficacious means of markedly improving the nutritive value of low-quality crop residues — in this case, wheat straw.

- Sheep, growing steers, and finishing steers showed significant weight gains. The livestock were able to digest between 65 and 70 percent of the diet organic matter and diet fiber.
- Dairy cows in early lactation that were fed diets of 12.5 to 37.5 percent treated wheat straw digested 66 percent of diet organic matter and 53 percent of diet neutral detergent fiber. These cows produced 31 kilograms of milk per day (27 kilograms per day of fat-corrected milk).
- When these same dairy cows in midlactation were fed diets of 20 to 60 percent treated wheat straw, they digested 68 percent of diet organic matter and 57 percent of diet neutral detergent fiber. Milk production was 25 kilograms of milk per day (24 kilograms per day of fat-corrected milk).

Recent research on oat hulls indicates a somewhat more favorable response than was noted with wheat straw. Laboratory screening of many low-quality fibrous feedstuffs also indicates that this treatment is effective in improving the feedstuffs' nutritive value.

George C. Fahey, Jr., professor of animal sciences



The Role of Ruminant Animals and Forages

Dan B. Faulkner and Don W. Graffis

In referring to a sustainable agriculture, "sustainable" implies a system that can function perpetually. If we can hope to create this kind of system, we must preserve and conserve the basic resources — soil, water, and air.

Water quality is an increasingly sensitive topic, particularly in reference to chemical contamination of drinking water. Land used for hay and pasture has a lower potential for contamination of surface water and groundwater than does land used for crops. Acre by acre, water runoff for hay and pasture is less than runoff from row crops. Water runoff from hay and pasture also is cleaner, containing less soil sediment and lower levels of fertility nutrients and pesticides. Hay and pasture fields filter the runoff water, keeping a greater percentage of water contaminants in the field.

Lower Chemical Inputs

Hay and pasture fields require lower levels of pesticides than do row crops. Although herbicides may be used to establish perennial hay and pasture fields, this occurs no more frequently than once every four years. Herbicides may be used to maintain hay and pastures as weed populations begin to take over or present a health hazard to livestock. Because these applications are rarely over the entire acreage, the total amount of herbicide normally used is small. Insecticides are used for hay production and for some of the most productive pastures. The total amount of insecticide applied per pasture acre is less than for hay, however, and both herbicide and insecticide applications are less than for corn.

Hay and pasture fields are fertilized at lower levels than row crops. Even on the more productive grass pastures, nitrogen (N) is rarely used at a rate above 150 pounds per acre. Although water runoff from hay and pasture fields may carry nitrogen, less nitrogen is lost than from row crops because of the filtering action of hay and pasture plants and the lower net amount available.

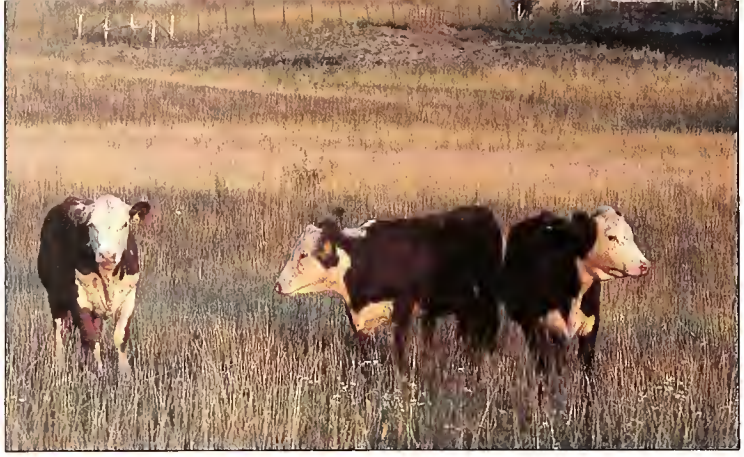
The Beef Advantage

Appropriate use of forages and manure can reduce input costs and soil erosion on many farms. Beef cattle fit into these systems because of their unique ability to use forages and prosper with minimal management inputs. Other ruminant animals may use forages, but they require more management. When forage is a limiting factor, weight gains will be reduced unless harvested or purchased feeds are fed. Profitable year-round systems of beef production not only maximize forage use by the grazing animal, but also minimize fertilization, grain feeding, and the use of purchased supplemental feeds. These systems reduce farm expenses and limit the use of hydrocarbon-based fuels for nitrogen fertilization and harvesting, which can supply farm enterprises with alternatives that are economically profitable, environmentally sound, and biologically efficient.

The integration of ruminants onto farms in the Midwest may improve productivity and profitability. Animal production is an excellent example of a value-added enterprise, because livestock and crop production can be mutually supportive. The challenge is to integrate economical production systems with available forage resources. In such systems, the ruminants can graze forages and recycle nutrients through the decomposition of manure. Rotational grazing of grass-legume pastures, sequential grazing of cool-season and warm-season grasses, and supplemental feeding of ruminants grazing crop residues can be used to control animal movement to further enhance the fertility contribution of manure.

These systems should also have a positive impact on soil productivity and water quality. As concern about the environment increases among farmers and the general public, interest grows about potential sources of surface water and groundwater contamination from agriculture. Cultivated row crop and pasture fields are potential sources of concern. Pasture management practices increasingly depend upon the use of agricultural chemicals, specifically nitrogen fertilizer. For agricultural production and water quality to coexist, it becomes more critical to evaluate sustainable management programs that minimize surface water and groundwater contamination.

Much of the land in the Midwest is subject to erosion, but appropriate rotation, tillage, and management practices can reduce erosion. The crop residues can be an economical feed resource, particularly if they are grazed and if some residue is left in the field to control soil



→ Cattle at the Dixon Springs Agricultural Center.

↓ Switchgrass at the Dixon Springs Agricultural Center.

erosion. For the farms that have some land unsuitable for row-crop production, sod-forming grasses and legumes can effectively control erosion.

Cool-Season Grasses

Cool-season grasses (for example, tall fescue, smooth bromegrass, orchardgrass, and Kentucky bluegrass) make most of their growth in the spring and autumn. This growth pattern often leads to a deficiency of summer pasture for ruminants. Split applications of nitrogen fertilizer can improve the yield distribution of cool-season grasses, but labor costs and the threat of water contamination may increase.

Because fescue is the predominant cool-season grass in Illinois, this midsummer problem is intensified. Much of this fescue is infected with an endophytic fungus (*Acremonium coeniphialum*) that reduces animal performance, particularly during the hot midsummer period. This fungus has been shown to reduce stocker cattle gains about 50 grams per day for each 10-percent increase in infection. Conception rate is also reduced when cows graze heavily infected tall fescue. Changing management practices such as the calving season can alleviate much of this problem. When seeded in pastures of infected tall fescue, legumes are particularly effective in reducing the toxic effects of the tall fescue endophyte.

Legumes Play Many Roles

Legumes are also important in forage systems as a source of nitrogen for cool-season grasses, improved forage yield during midsummer, and high-quality nutrients for the animal. Legumes grown with cool-season grasses can improve the pasture's summer productivity as well as eliminate the need for nitrogen fertilizer. Legumes can be added to grass pastures with no-till seeding systems to meet the nitrogen needs of the associated grass and improve the feed nutrient value of the pasture for the grazing animal.

Legumes produce nitrogen symbiotically with the proper Rhizobium bacteria. This symbiotically produced nitrogen presents little risk of contaminating surface water or groundwater. The nitrogen is produced, stored, and released from nodules on the legume root. Because the release rate is relatively slow, associated grasses or the legume plants themselves use the released nitrogen for growth.

Legumes reduce the dependency on petroleum-derived nitrogen but may require pesticides and additional lime, phosphate, potash, and other minerals to maintain high productivity. A substantial energy savings could result, however, because about 33 percent of the energy used in U.S. agriculture today is for nitrogen fertilizer.

Research at Illinois has shown that adding alfalfa can increase the rate, extent, and overall digestibility of the diet for ruminants. Legumes have higher concentrations of crude protein, total nonstructural carbohydrates, and digestible dry matter with lower concentrations of cell-wall constituents (fiber) compared to grasses. Therefore, legumes can effectively supplement forages of lower quality when added to the diet at the rate of 15 to 30 percent.

Legumes can effectively improve animal performance when grazed and persist well when used in a rotational grazing system. Sequential grazing demonstrations on southern Illinois farms have shown animal gain per acre that would give similar returns to row crops, based on commercial grazing costs.

Warm-season grasses such as big bluestem (*Andropogan geradii* Vitman) and switchgrass (*Panicum virgatum* L.) produce most of their growth in the summer and provide an alternative forage system for midsummer. The different growth patterns of cool-season and warm-season grasses permit a complementary pasture system to be developed. Furthermore, warm-season perennial grasses require little nitrogen for high yields. We have evaluated warm-season grazing systems for the past four years and found that more cattle can be grazed than on cool-season grasses alone, but animal performance decreases slightly.

It is important to minimize the use of harvested forages in beef systems. Forage harvesting methods are energy-intensive and use of stored forages may result in 40 percent waste during harvest, storage, and feeding. Reducing the amount of harvested forage fed to beef cattle may be possible if the forage is accumulated, winter cover crops are grown, or crop residues are used for grazing in late fall or winter. It would be most efficient to use harvested forages only when necessary due to snow cover or lack of pasture.

Although grazing is the most economical part of the beef system, it cannot be used without an economical way of wintering ruminants. The total system must be considered as one begins to apply available technology to produce livestock economically. Producers need economical forage-based systems to improve productivity and water quality.

During the past decade, studies worldwide have clearly shown that nitrates and some pesticides are being delivered to groundwater from routine agricultural practices. Regionally, in response to hydrologic settings, nitrates in groundwater have increased in a direct, linear fashion, paralleling the increased use of nitrogen fertilizers. Many studies show a direct relationship between the nitrate concentration in groundwater and nitrogen fertilizer rates. Deterioration in surface water quality has also been linked to applying nitrogen fertilizer on pastureland.

Our goal is to combine crop residues, winter cover crops, and forage resources into economical, environmentally sound production systems. Work in this area will continue at the Dixon Springs Agricultural Center and will be initiated soon at the Orr Agricultural Research and Demonstration Center.

Dan B. Faulkner, assistant professor of animal sciences, and Don W. Graffis, professor of forage crops, Department of Agronomy

□

Producing Fuel from Wastes and Other Biomass

Donald L. Day and John R. North

As world oil resources dwindle or become interrupted, interest increases in alternative energy resources. Livestock wastes, crop residues, and other sources of biomass are potential sources of renewable fuels, both liquid and gaseous.

Liquid fuels (ethanol, butenol, and vegetable oils) have a highly concentrated energy content and are suitable for mobile uses. Gaseous fuels (methane and hydrogen) are less concentrated and better suited for stationary uses, although they can be compressed or even liquified, at considerable expense, for mobile uses.

One University of Illinois project examines the feasibility for an integrated biomass energy system for an Illinois farm. Funded in part by a grant from the Illinois Department of Energy and Natural Resources, the project is part of the work at the University's Swine Research Center, which has a capacity equivalent to a farrow-to-finish unit marketing 3,000 hogs per year.

This totally enclosed, modern confinement unit has partially slotted floors. The manure produced from some of the buildings is scraped from under the slats several times per day to a central sump and pumped to an anaerobic digester to produce biogas that is about 60 percent methane, as compared to the almost 100 percent methane in natural gas.

The tank of the digester consists of four compartments: the main reactor, sludge storage, gas processing, and gas storage. Incoming manure is mixed and preheated in a separate tank (Figure 1). The digester is insulated with polyurethane and sealed with a spray-on rubber lining. The part of the tank that is not buried is mounded over with earth for additional insulation. Because the tank is too large to transport, it was built on site.

Biogas produced is being used in an engine-generator that consists of a 300-cubic-inch, six-cylinder industrial engine coupled to a 25-kilowatt synchronous generator. The engine-generator is controlled by an automatic transfer switch that is activated by either a utility power failure or a programmed time clock. The biogas should provide 250 kilowatt-hours

↑ An overview of the University of Illinois Swine Research Center. The digester is located between the buildings and the lagoon.

of electricity per day, about half the farm's electrical load. The electricity can be used to displace purchased electricity, to reduce peak power demands, and to provide standby power. Although there have been numerous design and operational problems with the digester and the generator, they have operated nearly automatically.

The digester at the Swine Research Center is envisioned as part of an integrated biomass energy system for Illinois agriculture. An intensive interdisciplinary study has shown that energy independence can be achieved by using 10 percent of an Illinois corn crop to produce ethanol liquid fuel needed to power the tractor, combine, and truck used in producing the crop. Figure 2 depicts the energy scheme.

In such an operation, a nearby feedlot uses the wet stillage as a protein supplement and thus avoids expending energy drying the stillage. Manure from the feedlot is the substrate for an anaerobic digester that produces methane as the process fuel for the alcohol plant. The ecological and energy cycle is completed when the sludge from the digester is applied to the cropland, thus furnishing nutrients required for another crop.

This totally integrated system provides an interesting ecological and energy cycle for the farm, while achieving considerable energy independence, using corn reserves, and helping the local economy. All major phases of the project — use ethanol production of stillage in livestock rations, methane production, and conversion of a diesel tractor to run on ethanol — have been researched; but converting the diesel engine is not practical at this time. A better approach uses diesel and ethanol in a dual-fueling mode.

Donald L. Day, professor of agricultural engineering, and John R. North, graduate research assistant

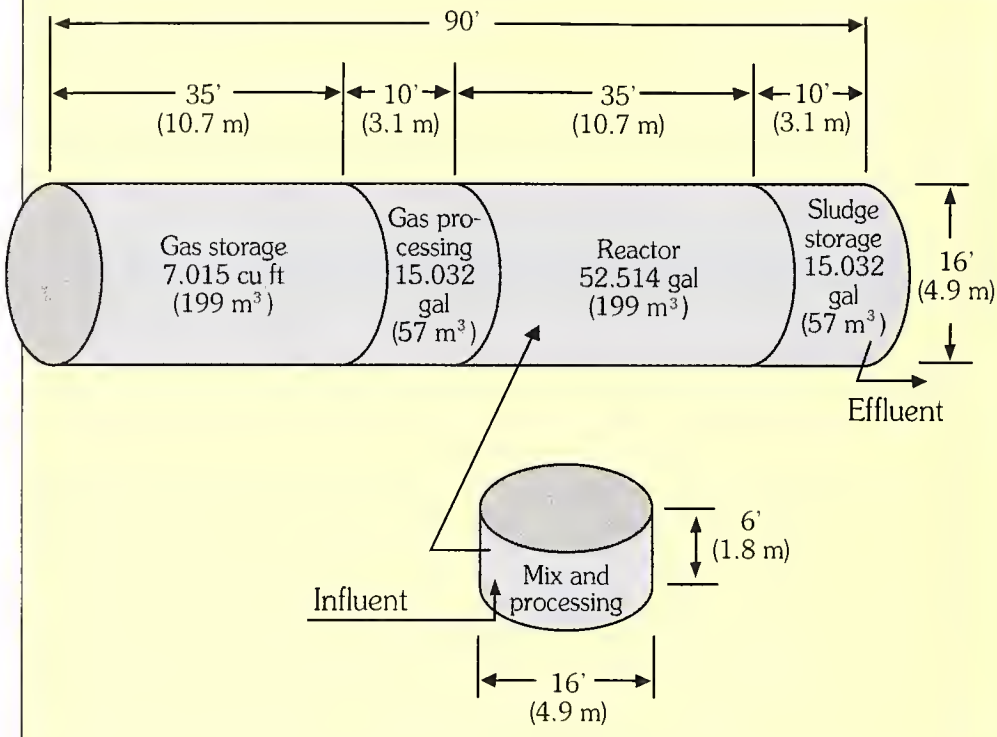


Figure 1. The anaerobic digester at the University of Illinois Swine Research Center was constructed by Energy Resource Systems, Dewey.

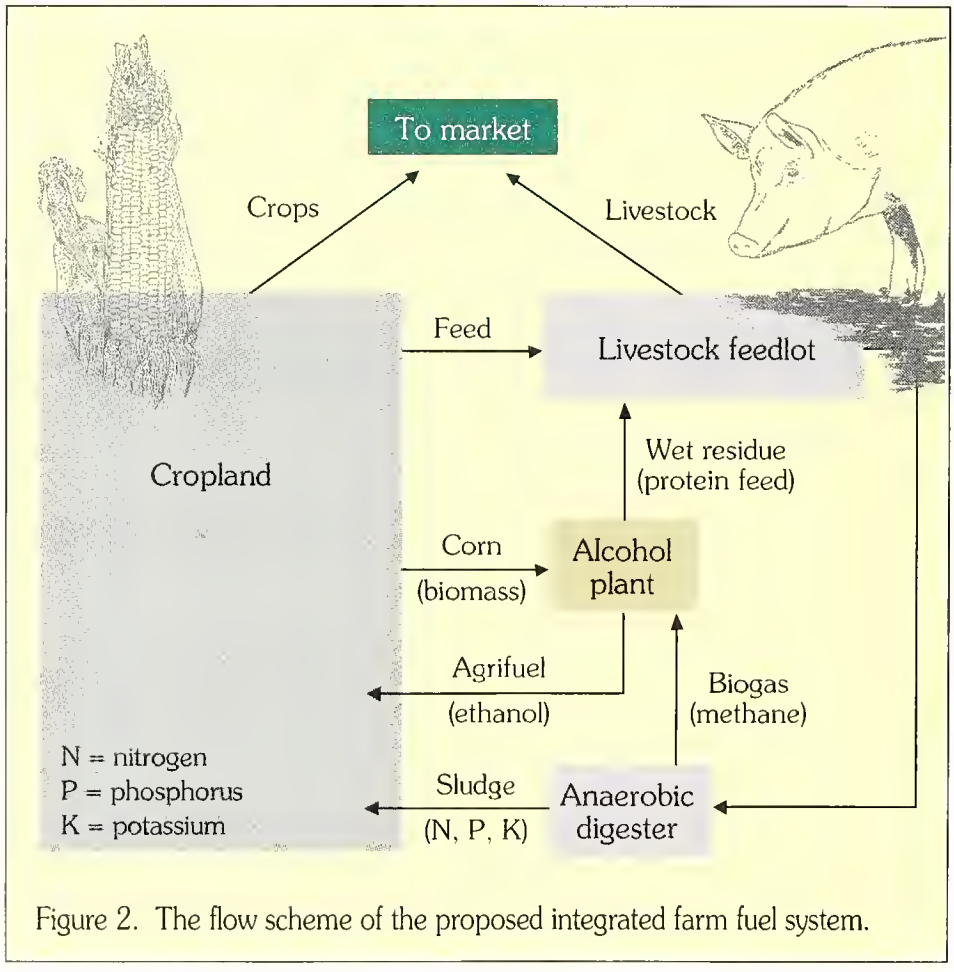


Figure 2. The flow scheme of the proposed integrated farm fuel system.

Grazing Management on Farm Woodlands

Ann Dennis

Habitat for native plant and animal species is scarce in Illinois. Farm woodlands provide much of this habitat, making farm activities that affect the quality of the woodlands a major concern among conservationists. Forest managers and conservationists have long recognized that livestock grazing can be destructive. However, most damage is not an inevitable consequence of grazing but rather the result of inappropriate livestock management practices.

Experience in other parts of the United States indicates that many negative impacts of woodland grazing can be eliminated by adjusting the number and distribution of animals and the time of use. Indications are that we can develop methods so Illinois farmers can simultaneously use woodland resources for livestock production and protect habitat quality. But we will need information on the links between specific grazing practices and specific levels and types of impacts.

Habitat quality problems associated with livestock grazing in woodlands are

- Destruction of understory plants that provide cover and food for wildlife,
- Reduced species diversity and ecological quality of understory plant communities, and
- Increased sediment production from ground bared by trampling.

As a first step in determining how specific livestock management practices may be linked to these problems, I conducted a survey in wooded portions of pastures under different types of cattle-grazing use at the Dixon Springs Agricultural Center in southern Illinois. All sites

↑ Ungrazed woodland.

↑ Woodland heavily used by cattle year-round.

↑ Woodland grazed by cattle in summer and fall only.

were in upland oak-hickory woodlands with overstory trees of similar size and density.

Negative impacts were most pronounced on sites where cattle were held for feeding during winter. These sites receive very heavy use during the winter and moderate use at intervals during the growing season. Shrubs and saplings were virtually eliminated, with native woodland herbs largely replaced by weeds. Bare ground was exposed on as much as 10 percent of the area.

Fewer negative impacts were evident on sites with other use. Woodlands used only after harvest of a hay crop on the adjacent open pasture actually had the greatest development of herb and shrub vegetation. These sites also had the richest understory flora, with a greater number of native woodland species than sites that had been protected from grazing for 15 years. Seedlings of the full range of overstory tree species were abundant on many sites, but saplings — mostly sugar maple and black cherry — were present only on sites protected from grazing.

"Woodlands used only after harvest of a hay crop on the adjacent open pasture actually had the greatest development of herb and shrub vegetation."

Overall, prospects seem favorable for identifying grazing management practices compatible with most habitat conservation goals. Heavy use in winter and moderate use throughout the growing season both seem to reduce habitat quality. However, dividing pastures to exclude livestock from woodlands until June or July may produce more habitat improvement than completely removing livestock. Further research may pinpoint critical times, use levels, and site characteristics that refine these general observations.

Implementing of grazing management plans aimed at conserving woodland wildlife resources seem to pair naturally with developing of native warm-season grass pastures for forage improvement. Pastures with large wooded areas are the best choice for warm-season pastures. The shade provided by the woodland has most value during the optimum period for use of these forages. This period is also when grazing may least damage the quality of the woodland habitat.

Ann Dennis, visiting assistant professor, Department of Forestry

↓ Cattle grazing at the Dixon Springs Agricultural Center.

Agroforestry

Timothy D. Marty

Black walnut trees are intercropped with clover.

The historical relationship between agriculture and forestry has been fairly consistent: agriculture was considered a dominant use and forestry a residual use of the land. Half the state was once forested, but only about 11 percent remains forested today. As concerns arise over agricultural sustainability, realization emerges that trees and forests have an important role to play in rural land use.

Agroforestry is a label often applied to a range of activities that integrate forestry and agriculture. Three general categories of activity may fall under the heading in Illinois: utilization of trees on primarily agricultural lands, tree farming, and intercropping of trees and crops. Windbreaks and stream corridors are the two most obvious examples of the first category. Trees used thusly have limited timber value but may provide benefits in terms of soil and water conservation, wildlife habitat, and scenery.

At the other end of the spectrum, tree farming (the intensive cultivation of trees for financial returns) may be considered a different form of agroforestry. Although the timing of costs, returns, and annual cash flow may be problematic in some instances, research indicates that managing lands for timber production can be a profitable long-term investment. Real, after-tax returns to forestry investments range from 4.8 to 14.9 percent. When the benefits available from government incentive programs such as the Conservation Reserve Program are included, the returns become even greater.

A more traditional use of the term "agroforestry" may refer to the intercropping of trees and crops in the same area. Of greatest interest in Illinois and throughout the Midwest is the multicropping of eastern black walnut trees in approximately 40-foot rows with alfalfa, clover, winter wheat, or soybeans grown between the rows. Crop returns help offset establishment costs for the walnut trees and provide annual income. When the walnut trees reach a size that effectively precludes crop production, nut yields begin to provide annual returns. Eventually, the walnut trees are harvested for either sawlogs or veneer. Alternative walnut multicropping regimes provide an annual equivalent value of $30 to $90 per acre. Although these cropping patterns are not widely practiced, there is interest in exploring opportunities for tree and crop intercropping.

More than 1.8 million acres, roughly 45 percent of the forest area of Illinois, are classified as being under farmer ownership. In addition, many thousands of acres of marginal cropland have been identified as suitable for conversion to forestry production. The Illinois Commission on Forestry Development noted, "Trees are a crop that, if properly grown on appropriate sites, can yield a higher long-term net return per acre than other crops." Clearly, the forestry and agricultural communities must explore the substantial opportunities that forestry offers for environmentally sound, sustainable land use.

Timothy D. Marty, assistant professor of forestry

A windbreak of Osage orange trees in rural Ford County

Donn Klor: One Farmer's Experiences

Tina M. Prow

Farmers are changing the way they think about agriculture. Top yields are no longer the driving force behind every operation — Illinois farmers are increasingly conscious of how investments affect their bottom lines and how agricultural practices affect the environment.

These farmers are striving for a sustainable agriculture, according to Donn Klor, a farmer in Buffalo, Illinois. Klor is past president of the Illinois Sustainable Agriculture Society (ISAS). Founded in 1988, the ISAS is a forum for growers, like Klor, who are concerned about the future of agriculture.

"Many farmers are exploring options for reducing inputs, such as less tillage or fewer chemicals. For some, these changes are strictly driven by economics," he said. "But more often, I'm seeing farmers change their farming practices because they're also concerned about food safety and groundwater quality; about soil erosion; and about leaving good farms for future generations.

"These economic and environmental goals are needed if we are to 'sustain' agriculture into the future."

A Conventional Operation

Klor considers his farm conventional — corn and soybeans, plus a few acres of wheat, oats, and alfalfa. He is open to unconventional ideas about farming, however, and searches for practices that reflect his interest in sustainable agriculture.

Reduced tillage and herbicide trials are among Klor's approaches toward sustainable agriculture. Reduced tillage saves nearly 40 percent on fuel for the operation, a low-input success, said Klor. Ongoing experiments with herbicide application techniques and rates have cut chemical use one-third to one-half, which Klor termed a success from both low-input and environmental standpoints.

Farmers are interested in a sustainable agriculture network to share ideas and successes. Last summer, the ISAS organized a tour of farms where producers are trying some of the sustainable agriculture practices being discussed today.

On display were crops planted into no-till fields; cover crops that add nitrogen to the soil and control erosion; herbicide experiments designed to test the effectiveness of reduced rates and band applications; and a no-till aerator used to break the plowpan without disturbing the soil surface. (The plowplan is the layer of soil just below the plow layer.)

"The ISAS has an interest in anything that can fall within the realm of sustainable or low-input agriculture, the 'low-input' referring to what is not spent to put farm crops in and the 'sustainable' referring to another way of looking at farming with a very definite environmental slant," Klor said.

Use of Chemicals Questioned

When farmers get together to talk about sustainable agriculture practices, he said, the conversation always turns to agricultural chemicals. Farmers seek alternatives to high-cost fertilizers and pesticides that pose risk to human health and the environment. Many farmers are reducing rates of chemicals and choosing those that pose the least risk over those that leach or are known carcinogens.

In addition, many farmers are intrigued by farm trials which show that cover crops appear to reduce the need for fertilizers and herbicides and to improve soil tilth. Although cover crops on his farm have been unsuccessful over the long term, Klor is convinced there is some potential for this centuries-old, "new" management strategy.

Still other farmers are moving away from chemical inputs and toward organic farming. According to Klor, organic farming can be sustainable, and many organic farmers belong to the ISAS; but sustainable agriculture is not exclusively organic farming.

"We embrace it, but we aren't organic. There's a market niche for organic products, but we don't think that the vast majority of the ag community is going to go organic. We see the trend as seeking out systems and products that are more environmentally sound," he said.

One problem he sees with organic farming is that few researchers or farmers understand how a particular system works, making it hard to identify and evaluate specific practices contributing to the success of an organic system.

Still, some organic farms are successful, and farmers are interested.

"If someone across the fence can grow 50 or 60 bushels of beans per acre and 150 to 250 bushels of corn and do it without going to the store to buy inputs, I'm extremely interested.

"I might be able to take part of an organic practice and put it on my farm and get similar results," he said. "It might reduce my costs or change a practice that's not good for the environment. But the information transfer isn't there. You have to seek people out who will show you what they do."

Farmers Seek Information

The lack of research and educational programs about organic farming and other practices associated with sustainable agriculture is a complaint of farmers around the state, Klor said. In most cases, farmers hear and read about practices; then they apply those practices on their own farms without direction from university researchers.

"A fellow on the ISAS summer tour said most of his information on cover crops came from the University of Illinois library, from books printed around the turn of the century," he said. "We think it's extremely important that researchers at land-grant and other schools take stock and realize they haven't done much work in cover crops and other alternatives for 40 or 50 years."

Klor said the ISAS considers the federal LISA (low-input sustainable agriculture) initiative one way to get quick answers to farmers' specific questions about cover crops, reducing tillage, adjusting chemical rates, and other practices that might lead to a more sustainable agriculture.

"I don't think LISA will eliminate the broad-based research," he said. "Instead, it can be considered extra money to target a particular project. With this designated research, and with renewed interest in applying our current knowledge and new technologies to some of the old practices, I think we have the ingredients for some fantastic programs."

Donn Klor cultivates his field.

Besides production research, farmers need research on effects of chemicals upon health and the environment, he said. As members of society, farmers count themselves among those who do not want potentially dangerous chemicals on foods, in the water supply, or harming wildlife. And cancer is increasingly a concern among farm families.

Klor said at least one study shows that a person who uses farm chemicals over 20 days a year is six times more likely to have cancer. "There are tremendous differences among herbicides; some are more dangerous than others, but the farmer often doesn't know the risk.

"We need labels that spell out the hazards so we can make better choices," Klor said.

Klor said health and environmental issues related to agriculture are likely to affect the 1990 and 1995 farm bills. Testifying in Washington for bills and hearings related to agriculture have convinced him that these issues are of prime concern to too many groups to be ignored.

Although he finds this level of interest encouraging, he sees some danger of health scares and overzealous legislation with so many people unfamiliar with agriculture involved in farm policy at the national level.

"Many diverse coalitions are interested in agriculture, and the industry has a lot at stake. But the common threads for all groups appear to be an interest in improving net income for farmers and in reducing environmental risk.

"I think these goals are attainable and that farmers who are part of the sustainable agriculture movement are working toward these goals," he said.

Tina M. Prow, Extension communications specialist, Office of Agricultural Communications and Education

Sustainable Agriculture: The Industry's View

Tina M. Prow

Although there is some confusion about what sustainable agriculture is and how Illinois farmers will implement it, the economic and environmental goals of this farming concept have drawn support from widely diverse groups and agencies in the state.

"The 'sustainable' part of the concept is all about farming the right way so that there are no problems with the food chain, with health, with groundwater, with keeping the soil in place — there can't be any opposition to that," said Donn Klor, past president of the Illinois Sustainable Agriculture Society (ISAS), a farmers' organization.

"These are things the general public is concerned about, and farmers have to address those concerns," he said.

Deborah Cavanaugh-Grant, resource planner at the Department of Energy and Natural Resources (DENR), worked closely with the ISAS as it developed in 1988, because members were interested in protecting groundwater quality, also a priority of the DENR.

"Sustainable agriculture has many definitions, including 'organic farming,' but it really is whatever people need to do in light of potential environmental problems and maintaining profitability for farmers, farm communities, and society," she said.

There is much to be gained through the sustainable agriculture movement, according to Virginia Scott, president of the Illinois Environmental Council. The Council represents a coalition of more than fifty environmental groups.

"We see the voluntary reduction of agricultural chemicals by using other techniques and technologies to maintain crop production as very positive from the standpoint of protecting water quality, soil quality and conservation, and health of the ag population," she said.

Although reducing chemical use is commonly associated with sustainable agriculture, this movement is not expected to affect sales at ICI Americas, Inc., an agricultural products company.

"I think most farmers are not abusing ag chemicals. They can't afford to pay for chemicals if they don't get a return on their investment," said Barbara Hook, an ICI representative.

Larry Werries, director of the Office of Intergovernmental Affairs and former director of the Illinois Department of Agriculture, agreed that economics motivate most Illinois farmers to use only those inputs necessary for operations. Profit is the key to any further reduction of inputs on a farm, he added.

"If farmers can maintain profitability and use no more outside inputs than those they can come up with right on their own operations, that's good; there is potential for those operations to be more benign to the environment. But without profit, the operation will not be sustained for very long," he said.

One benefit of the sustainable agriculture movement is that it may help make farmers more aware of management practices that pose the least threat to the environment, he said.

He cautioned, however, that more research is needed on many practices advocated for sustainable agriculture. Similarly, Len Gardner, executive director of governmental affairs at the Illinois Farm Bureau, said there is a particular need for research under real-farm, practical conditions and for research on farm management.

"Farmers have generally looked at how they can reduce inputs, and in the past few years we've seen more pest scouting and more reduced tillage," he said. "But, as farmers move away from ag chemicals, they've got to be willing to put in more management time and be better managers.

"It takes top-quality management to reduce the number of trips over a field, or reduce tillage, or scout for pests."

Until there is more research and education on many aspects of sustainable agriculture, it represents added risk on some farms, he said.

Tina M. Prow, Extension communications specialist, Office of Agricultural Communications and Education

Solar Salt Ponds

Ty A. Newell and Donald L. Day

A one-half-acre salt-gradient solar pond warms the lop-eared boarders at the new Imported Swine Research Laboratory on the campus of the University of Illinois at Urbana-Champaign (UIUC). This new facility uses a technology that borrows concepts derived from studies of various natural lakes that contain salt concentration gradients.

Models in nature. Although the technology is new, as long ago as 1902, the German scientist Kalecsinsky studied the natural solar ponds in Transylvania and suggested building artificial solar ponds to select and store solar energy for home and industrial use.

Natural solar ponds occur where salt deposits (sodium chloride) nearly saturate the lower levels of natural lakes, while the rain and overflow wash the surface, keeping it at low density.

Because salt water is denser than fresh water, normal convection is prevented; solar energy that penetrates the water heats the bottom of the ponds. Because convection cannot occur, which normally would make the water temperature uniform throughout, temperatures as high as 70°C (160°F) have been reached in these natural lakes.

In artificial ponds such as the one providing space heat for the Imported Swine Research Laboratory, the water temperature at the lower levels can rise to 70° to 90°C (160° to 194°F), with the surface temperature remaining close to the ambient air temperature.

Mechanisms. Establishing a salt gradient in the pond prevents convection, so that the salt concentration varies from near zero at the surface to 20 to 25 percent at the bottom of the pond. The presence of the salt gradient results in higher fluid densities at the lower levels of the pond than near the surface, thus preventing the warmer fluid at the lower levels from moving upward.

As shown in Figure 1, a salt-gradient solar pond normally consists of three zones: a thin convective zone at the surface, a nonconvective gradient zone that provides thermal insulation in the middle, and a heat storage zone at the bottom. The pond collects and stores solar energy all year, and the available thermal energy can be extracted via a heat exchanger.

UIUC project. Sponsored in part by the Illinois Department of Energy and Natural Resources, the International Salt Company, and Gundle lining systems, the UIUC project has three objectives.

- To develop and demonstrate a basic but full-scale pond design that can be replicated for various purposes (such as grain drying, space heating, and providing low-temperature industrial process heat).
- To assess accurately the costs of constructing and operating a solar pond in Illinois.
- To monitor pond performance for developing operation guidelines and projecting the economic potential of salt-gradient solar ponds.

Specifications. The project has drawn on technology developed at several research ponds around the country, specifically the one-fourth acre pond at Argonne National Laboratory. The Argonne pond is about 16 feet deep, with sloping sides. The UIUC pond is lined with a high-density polyethylene (HDPE) liner. The liner was manufactured in 22-foot widths and has four to five times fewer seams than other liners, thus less potential for leakage.

Establishing the salt gradient required 2,000 tons of "junk salt," a finely powdered by-product of the crushing and handling processes at salt mines. To prevent the release of salt into the surrounding environment, a one-quarter-acre evaporation system recycles the salt into the pond. Heat exchangers for extracting heat from the ponds are off-the-shelf cupronickel types that have been used successfully at other pond sites.

Productivity. A commercial solar pond of this type would produce heat at a cost of $2.25 per million Btu, compared to $5 for natural gas. Expanded to a full acre, a solar pond could produce thermal energy worth $9,100 per year, providing for cost recovery in nine years. Applicable depreciation and tax credit could reduce the payback time even more.

Ty A. Newell, associate professor of mechanical engineering, and Donald L. Day, professor of agricultural engineering

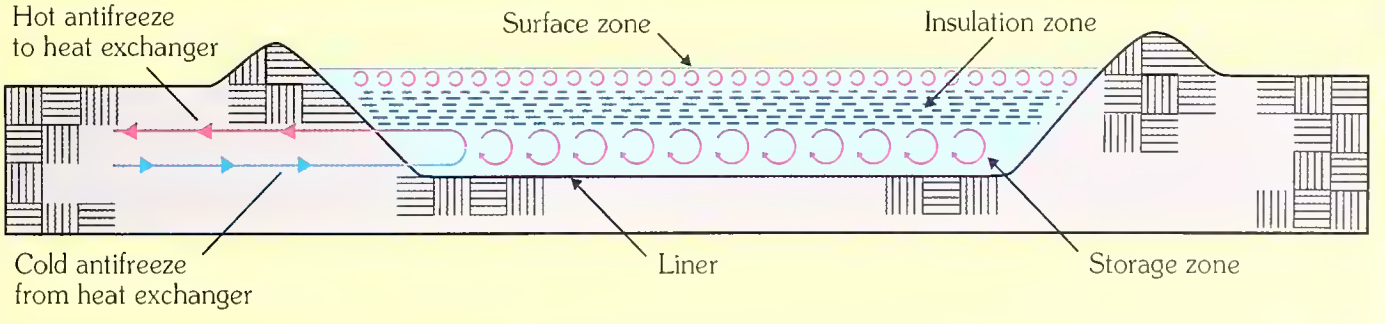


Figure 1. Schematic of salt-gradient solar pond.

Horticultural Alternatives

Schuyler S. Korban

The most concrete evidence supporting the need for low chemical use in agriculture comes from last spring's uproar over the treatment of apples in commercial orchards with Alar — also known as B-9, daminozide, and SADH. The controversy over this one chemical, which enhances red coloration of apples and prolongs fruit hanging on trees, has devastated the U.S. apple industry. Even after the manufacturer halted sales of Alar for food crops and apple growers promised not to use this chemical on the 1989 crop, severe damage has been done and millions of dollars have been lost.

The Environmental Protection Agency is reviewing several chemicals used for fungicide and pesticide control on various horticultural crops. These chemicals are suspected of being hazardous to human health and contributing to air pollution and water contamination.

At the University of Illinois, we have been working for more than 35 years to eliminate the use of chemicals on apples. By introducing genetic resistance into the apple, our goal is to fight off diseases and insects that attack apples.

This work has been quite successful. In collaboration with Purdue and Rutgers universities, the apple breeding program at the University of Illinois has named and released nine newly developed disease-resistant apple cultivars (Table 1). These cultivars can be grown in commercial orchards and the home backyard with 60 to 70 percent fewer chemical spray applications than needed by popular commercial cultivars such as 'Red Delicious', 'Jonathan', or 'Granny Smith'.

This is a significant reduction in the use of chemicals on apples. The new cultivars not only have high quality and attractive appearance, but they can be marketed to the consumer as a "healthful" fruit grown with few chemicals.

Our research efforts include work on developing multiple disease-resistant apple cultivars and also attempting to add insect resistance into our cultivars.

A major direction of the current apple genetics program is to utilize genetic engineering techniques to manipulate the apple. Our goal is to speed up the process of developing disease- and insect-resistant apple cultivars without making major changes in fruit quality and appearance or tree habit and shape.

We are developing cell and tissue culture techniques to regenerate plants from apple leaf tissues and to establish disease-screening techniques for test-tube-grown plants.

We have also conducted basic work at the DNA level. We are now developing techniques to isolate genes involved in disease resistance and establishing ways to transfer these individual genes to apple leaves and then regenerate whole plants that not only carry these specific genes but also express these genes when attacked by a pathogen. In essence, they will "fight off" disease biologically without chemical spraying.

Two new Station bulletins about apples (Bulletins 789 and 790) are available for $1 each from the Office of Agricultural Communications and Education, (217)333-2007.

Schuyler S. Korban, associate professor of plant genetics, Department of Horticulture

'Dayton', a new disease-resistant apple cultivar.

Table 1. Maturity Date and Color of the Disease-Resistant Apple Cultivars

Cultivar*	Maturity relative to 'Red Delicious'	Maturity relative to 'Jonathan'	Fruit color
	weeks		
Prima	–4	–3	red
Priscilla	–2	–1	red
Priam	–1.5	–0.5	red
Sir Prize	0	+1	yellow
Redfree	–7	–6	red
Jonafree	–1	0	red
Dayton	–4	–3	red
William's Pride	–7	–6	red
McShay	–3	–2	red

* All cultivars were released in cooperation with Purdue and Rutgers universities; Priam was released in cooperation also with the Institut National de la Recherche Agronomique in France; and McShay was released in cooperation also with Oregon State University.

Sustainable Agriculture at the University of Illinois

Harvey J. Schweitzer

Within recent years, "sustainable agriculture" has become commonplace on the agendas of public policy makers, academics, consumers, environmentalists, agribusinesses leaders, and farmers. Broadly defined, the concept accommodates many interests of people advocating organic farming, regenerative and alternative agriculture, and low-input and resource-efficient farming systems.

Sustainable agriculture has been variously described as a new era in farming and a back-to-basics movement, as a philosophy and a set of specific practices. Embraced by many who are concerned with the environmental impacts of agricultural practices, sustainable agriculture is criticized by others who claim that it promises more than it can deliver in environmental, economic, and social benefits.

At the national level, sustainable agriculture is best known as LISA, low-input sustainable agriculture. Federally funded, LISA is a nationally and regionally administered program of research and education aimed at developing and promoting farming methods that will pose fewer environmental and human health threats, conserve natural resources, and be more sustainable than are practices and technologies now widely used.

LISA's origin lies in the Agricultural Productivity Act passed in 1985 as part of the Food Security Act. Prospects of long-term federal funding are uncertain, but most observers of agricultural public policy agree that environmental and food and water safety concerns will receive major attention in the 1990 farm bill.

Although the federal LISA program is a significant initiative, the most important incentives for action are coming from public concern about the environmental and health impacts of certain agricultural practices. In addition, farmers are trying to reduce their purchased inputs.

UIUC Initiatives

Specific initiatives were taken by the College of Agriculture in 1988 to provide leadership and focus for issues in sustainability. In the Agricultural Experiment Station (AES), a coordinator for research and education programs in sustainable agriculture was named, with support from the Cooperative Extension Service (CES) and the Dean of the College.

An ad hoc committee was named by units in the College of Agriculture, the College of Veterinary Medicine, and the Illinois Natural History Survey. The committee has facilitated the development and submission of proposals to the North Central Region LISA program, initiated an agroecology newsletter and a seminar series, helped local leaders develop a legislative proposal to support on-farm research, developed contacts with agencies and farm organizations, and in general encouraged the development of public education programs, including in-service training for CES staff.

A significant venture stemming from committee discussions is the development of an agroecology curriculum in the College. Efforts are also also under way to link the College's domestic and international programs in sustainable agriculture.

Although some proponents would like to label these developments a "new birth" in the College, others view them as a phase in the evolution of programming in response to societal needs. What is perhaps unique is that the program name provides a focal point for public contact and a more tangible indication of the College's commitment to an environmentally sound, sustainable agriculture.

A Rich Heritage

The College's initiatives in agricultural sustainability and agroecology build upon a rich heritage of both research and education. In fact, the establishment of the Morrow Plots on the Urbana-Champaign campus in 1876 and the initiation of statewide soils surveys in 1902 are often referred to as the beginnings of an unbroken program of research dealing with land resources.

The work of Cyril G. Hopkins at the turn of the century is noteworthy as we reflect on the components of sustainability. A basic concept in his system of permanent soil fertility was farmers as stewards of the soil, with the duty to pass on to their descendants land that is richer than when they took over its management. Hopkins's leadership in establishing facilities around the state for field research emphasized doing research under as near-farm conditions as possible.

The contributions by the Dixon Springs Agricultural Center near Simpson, are impressive, with its emphasis on erosion control, pasture renovation, forage utilization, soil fertility experiments, sheep and

beef production, and tillage experiments. It was there that George E. McKibben, the "father of zero-tillage," pioneered work that stimulated widespread interest in reducing tillage costs and conserving soil.

Not to be overlooked are the work in farm management, the establishment of the Farm Business Farm Management (FBFM) system to assist farmers in record keeping and management strategies, and the emphasis on farm and home development, followed by rural development and Rural Route assistance programs.

Especially important to the College's recent initiatives are the programs in integrated pest management (IPM). Started in the early 1970s, this systems approach incorporates pest control procedures that result in favorable socioeconomic and environmental consequences. Specifically, the use of alternative strategies in pest management provides a sound foundation for sustainable agriculture programs.

By contrast, much of the College's research may be referred to as "component research," which provides basic information about soils, crops, tillage, fertilization, insect and disease control, and farm management essential to developing sustainable agricultural systems. Data for much of the research span a period of many years and are therefore invaluable sources of information.

↑ Hand application of pesticides using appropriate safety gear at McKibben Plots, Dixon Springs Agricultural Center.

A farm in Kane County.

Challenges

The College of Agriculture is in a unique position to lead in agroecology programs and to address problems of agricultural sustainability. As a land-grant institution, the entire University has a mandate to address societal issues. The College has the disciplinary diversity and the expertise to deal with ecological issues relating to farming, the research capability and the educational network to generate and disseminate information, and mechanisms for citizens' input into planning.

A number of challenges must be met if the University and the College are to effectively address agroecological and sustainability issues.

The research base for sustainability must be strengthened.

The research agenda must be flexible. New technologies, such as developments in biotechnology and genetic engineering, and the changing economics of agriculture will alter the nature of problems to be researched.

Greater emphasis must be placed on multidisciplinary research involving several academic disciplines, including those outside the College of Agriculture.

Incremental advances in research and education must be sought. Major breakthroughs may occur, but the emphasis must be on taking significant small steps as opportunities arise.

Funding for applied research must be obtained. Public support for the Leopold Center for Sustainable Agriculture at Iowa State University and the recent $2 million endowment from the Charles Stewart Mott Foundation for Michigan State University programs in sustainable agriculture are but two examples from nearby states.

The research agenda in sustainability must be broad, including studies of alternative agricultural enterprises, new uses for traditional crops, and market development, as well as economic and sociological studies of the impacts of changing technologies, practices, and public policies on agriculture, families, and communities.

Systems must be an emphasis in research. Component research will continue to contribute to better understanding farming systems' complexities.

Research and education on sustainability must be closely linked. On-farm experimentation and demonstration should be a part of the endeavor.

Environmental and ecological concerns and the issue of sustainability in agriculture are high on the agenda for the College of Agriculture. As part of a major research and educational institution, the College has unique strengths and opportunities to make significant contributions to agroecology.

Harvey J. Schweitzer, professor emeritus of agricultural economics and former assistant director, Agricultural Experiment Station

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The Promise of Biotechnology for Sustainable Agriculture

Lila O. Vodkin

Awareness of how agricultural practices affect ecosystems has increased in recent years. The growing interest in protecting the environment and in conserving the productivity of agricultural land coincides with an expansion of knowledge and opportunities in biotechnology — genetic engineering, molecular biology, and recombinant DNA.

We may ask how the advances in biotechnology will affect agricultural practices and products. Basically, genetic engineering is an extension of breeding methods that have been practiced for thousands of years to improve crops and animals. In traditional methods, crosses or sexual matings are made between individuals with desired characteristics, and the offspring are evaluated with respect to certain criteria — such as yield, milk production, and disease resistance.

Gene transfer. The revolutionary change of the last decade is that genes controlling plant and animal traits can now be physically isolated, manipulated, and transferred by other methods. Individual genes can be transferred across species boundaries — for example, from corn to tomato or from bacteria to plants and animals.

Because a complex plant or animal consists of more than 100,000 genes, the transfer of one or a few genes is not going to change the basic qualities of the recipient species. A tomato plant with a corn gene in its makeup is still a tomato; a bacterium containing a human gene is still a bacterium.

Concerns have been raised, however, that these new creations may have negative environmental effects. Caution is necessary, especially in the case of microorganisms that cannot be contained as easily as domesticated plants and animals. Stringent criteria and reviews by local, regional, and national agencies are in place to ensure that bioengineered organisms will not adversely affect the environment. On the contrary, genetic engineering will likely have substantial benefits for less intensive and more productive agricultural practices.

Super plants. One recent development in this area has been the production of viral resistance in tomato plants by transferring a gene from a strain of tobacco mosaic virus directly into the DNA of tomato plants. The viral gene produces a protein necessary for the proper coat structure of the virus.

"Recombinant" tomato plants containing the viral gene express the coat protein continuously but do not show any of the adverse symptoms associated with viral infection. More importantly, the coat protein provides resistance to infection by the virus. In a sense, the virus has been fooled into thinking that the tomato plant is already infected because the plant produces the viral coat protein.

The benefits of engineering resistances to viral, bacterial, fungal, and insect pests will lie in reducing the chemical control needed to maintain healthy, productive plants. In other areas, the use of biological rather than chemical control mechanisms can specifically target a particular pest and reduce reliance on pesticides with a broad spectrum. Chemical control will probably always be necessary to some extent. More futuristic possibilities from biotechnology may lie in producing common soil microorganisms that can detoxify pesticide residues.

The most significant impacts of biotechnology probably cannot be predicted. Many exciting problems of plant and animal development and response to biotic and abiotic stresses in the environment remain to be explored. With few exceptions, the genes that control important agronomic traits such as yield and disease resistance are currently equivalent to "black boxes," their mechanisms unknown. As genetic engineering and biotechnology provide the tools to begin dissecting these complex interactions, unanticipated applications will emerge.

Lila O. Vodkin, associate professor of crop molecular biology, Department of Agronomy

Agroecology Defined

John M. Gerber

Aristotle wrote that "in natural science it is the composite thing . . . which primarily concerns us, not just the materials of it, which are not found apart from the thing itself." Today Aristotle might have difficulty finding agricultural research on "the composite thing," as science becomes more and more specialized. Yet, to develop sustainable agricultural systems, scientists must think holistically. Some scientists have proposed a new science, agroecology or ecological agriculture, that applies ecological thinking to agricultural systems.

Agroecology is the science devoted to studying agroecosystems, which are complexes of air, water, soil, microorganisms, plants, and animals that humans have modified for agricultural production. An agroecosystem may be a single field, a farm, a community of farms, or an entire region of the country, such as California's Imperial Valley. The goal of agroecology is to understand these complex agricultural ecosystems and to develop technologies to sustain them.

Agroecology uses basic principles of nutrient cycling, predator-prey relationships, and species competition and cooperation to provide a better understanding of agricultural systems. Some properties of an agroecosystem that are useful for scientific measurement are productivity, stability, sustainability, and equitability. When these measures are used to describe an agroecosystem, they are defined in terms of desired socioeconomic outcomes — that is, they have social value. Agroecosystems may be judged according to the goods and services produced, their contribution to human needs or happiness, and their relative distribution among the human population.

For example, the traditional criterion for evaluating an agricultural system's success is productivity. Irrigation is generally considered a social good because it improves productivity. Irrigation also improves a system's stability because farmers no longer depend on unreliable rainfall. But the system is sustainable only if it does not cause environmental problems such as increased soil salinity, erosion, or water shortages. Further, equitability may suffer because not all producers have access to a source of irrigation water. Agroecology attempts to use these properties and others to conceptualize complete agricultural systems.

Expanding on the ecological studies of conservationist Aldo Leopold, some scientists are embracing a revitalized land ethic. This approach allows humans to perceive value in self-sustained agricultural systems that are less resource intensive and that enhance environmental quality and human wellness.

John M. Gerber, assistant director, Agricultural Experiment Station

↓ Irrigation may improve short-term productivity while decreasing long-term sustainability.

In Progress

College of Agriculture Student Survey

Sustainable agriculture is not a top priority for today's college students, according to a recent survey of 250 first-year agriculture students. The survey indicates that the students need more information on organic and sustainable agriculture than they have upon entering college.

Of six issues facing agriculture today, the students ranked organic and sustainable agriculture as the least important. Their top four priorities were decreasing pesticide use, increasing profitability, reducing soil erosion, and maintaining family farms.

Sustainable and organic agriculture were the two issues about which the students felt least knowledgeable. Slightly more than one-quarter of the 250 students in the introductory agricultural survey course indicated that they had insufficient knowledge to rank either issue.

Although students from rural backgrounds were slightly more likely to rank organic or sustainable agriculture higher than students from urban backgrounds, rural students were four times more likely to feel that they had sufficient information to rank issues related to pesticide use, soil erosion, profitability, and family farms. Slightly more than one-fifth of the rural students and nearly one-third of the urban students indicated insufficient knowledge to rank either organic or sustainable agriculture.

Urban students were less likely than rural students to rank any of the issues, but they were two to three times more likely not to rank sustainable or organic agriculture.

The survey was sponsored by the University of Illinois's College of Agriculture Office of Resident Instruction and the Ad Hoc Committee on Sustainable Agriculture. For further information, call Ann Reisner, (217)333-4787, or Gerry Walter, (217)333-9429, assistant professors, Agricultural Communications and Education.

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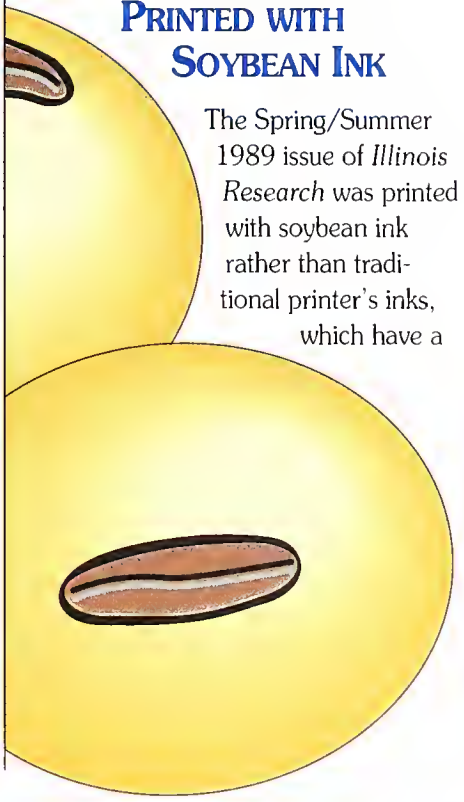

The Spring/Summer 1989 issue of *Illinois Research* was printed with soybean ink rather than traditional printer's inks, which have a petroleum base. Petroleum-based inks contain 25 to 50 percent volatile organic compounds (VOCs) that evaporate and leave a smell. Soybean ink contains less than 3 percent VOCs and has no smell. Soybean ink also produces sharper images and brighter colors than traditional inks.

Because petroleum costs have risen again recently, soybean ink has become an economical, as well as safer and renewable, alternative for printers. We hope to use soybean ink whenever possible for future issues.

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First Open House, A Success Story

An enthusiastic crowd of 12,000 people came to the first annual University of Illinois College of Agriculture Open House. Visitors on March 2 and 3 quickly learned that the College focuses on a lot more than just farming.

A bigger and even better Open House is already being planned for next year. Circle March 1 and 2, 1991, on your calendar!

At the 1990 Open House, faculty and students welcomed visitors at the Stock Pavilion, event headquarters. A brief slide show featured the 125 demonstrations, displays, and lectures that were taking place in nine buildings on the south campus.

Visitors saw research projects that they had read about: machine robotics, biodegradable plastics, and the College's

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famous Chinese pigs. Visitors sampled popcorn, soy-based cookies, and cholesterol-free milk. They learned about acid rain, agroecology, world markets opening in Indo-China and Eastern Europe, Lyme disease, artificial intelligence applications, tissue culture propagation, global warming, and the Egyptian mummy project. They watched a dog training demonstration or toured an automated dairy, the new greenhouse complex, and the Meat Science Laboratory. They attended minicourses on gardening and flower arranging or took a computerized nutrition quiz. Fashions from the 50s were on display. Lunch was even available at "Hotel Bevier" with the Restaurant Management Program.

New Agroecology Series

The Agroecology Program Papers are available to encourage dialogue about the economic, social, and environmental impact of production agriculture. The papers, which do not undergo formal peer review, report the viewpoint of the author, not necessarily the views and policies of the University of Illinois College of Agriculture or the Agroecology Program.

The postage and handling charge is $2 per paper, payable in advance to the University of Illinois. Copies are free to University of Illinois faculty and staff. For more information or to order papers, contact John M. Gerber, Assistant Director, Agricultural Experiment Station, University of Illinois, 1103 West Dorner Drive, Urbana, Illinois 61801, (217)333-1969.

Illinois Research
Spring/Summer 1990

Illinois Research

Agricultural Experiment Station
Spring/Summer 1990

Value Added in the Home

College of Agriculture, University of Illinois at Urbana-Champaign, Volume 32, Numbers 1/2

The Cover

A page from the family album reminds us of a simpler time.

These photos are from the archives of the Office of Agricultural Communications and Education.

"At a time unlike any in the past, we must envision the future."

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The Illinois Agricultural Experiment Station provides equal opportunities in programs.

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Value Added in the Home

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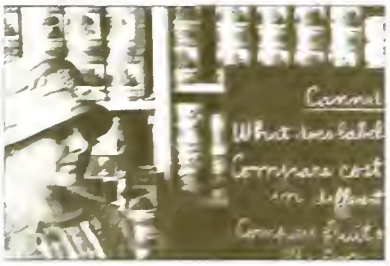

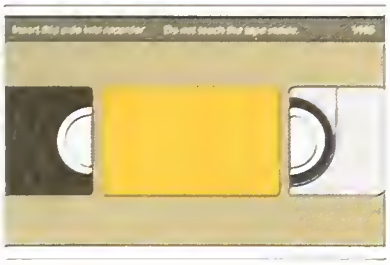

Managing Life's Basics

Donald A. Holt

Within the last five years, two academics who are also mothers and homemakers told me that they could think of nothing within the home economics subject matter that deserved research attention or that should be taught beyond the high school level. Surprised by their opinions, I asked if they really believed we knew everything about foods, nutrition, family relationships, child development, textiles, apparel, interior design, and family and consumer economics. Their answers made me realize how much about home economics we take for granted.

Because of their own relative affluence, advanced education, and ready access to information, the two women and their families regularly bought and used some very sophisticated technology and information. Much of the technology inherent in the products and systems that the women used was invisible to them. They also acquired information from the mass media. Apparently though, they were unaware that important technology and information used routinely in homes were developed, evaluated, and refined within home economics research and educational programs and by private-sector scientists and managers trained in home economics research and education programs.

These women had professional management responsibilities. But they obviously did not equate managing home resources and activities with managing the production activities of a business or managing the service activities of a service institution. They agreed that the management of resources and value-added activities in many homes is poor, but they attributed this to the natural human condition rather than inadequacies in technology or information available to families.

The women acknowledged that research and higher education have profound effects on the management of commercial activities. But they had not considered the potential of research and higher education in reducing the cost and improving the quality and management of value-added activities in the home.

This issue of *Illinois Research* is intended to make us all more aware of the complex interrelationships between basic human and physical resources and value-enhancing activities within our homes, the enormous economic and social significance of these resources and activities, and the great potential benefits from their improved management.

Donald A. Holt, Director, Illinois Agricultural Experiment Station

Household Production: Concepts, Issues, and Challenges

Andrea H. Beller and Sheila Fitzgerald Krein

Historically, families and society in the richest to the poorest nations have benefited from the economic and social *value added in the home*. Families carry out activities vital to our well-being. If these activities are unsuccessful, social institutions must intervene. Income-maintenance programs; prisons and the court system; and the special agencies and programs to handle drug abuse, alcoholism, teen pregnancy, mental health, illiteracy, AIDS, and child abuse — all are examples of such institutions. How families manage their resources also affects economy-wide behavior through its impact on consumer demand, employment, the economy's human capital stock (people), and its physical capital stock (machinery, factories, stores, and finished and unfinished materials).

Concepts

Household production may be defined as *commodities* produced in the household with inputs of market goods and services and the time of household members. These commodities — good health, educated and responsible children, nutritious meals, financial management, a happy home, love, psychological support, and self-esteem — yield satisfaction for families.

Distinct from market goods and services, these commodities are produced and consumed by households, cannot be purchased in the marketplace, and have no market prices. This does not mean that these commodities are valueless.

The resources necessary for this production — income and time — are scarce and have competing uses. We are all limited to 24 hours a day to allocate among work in the marketplace, work in the household, and leisure time. Just like market goods and services, time has a cost. If we work an hour in the household, we forego the income that we could have earned in the labor market. That income could have purchased market goods and services to substitute for our time in producing household commodities.

Comparing household production to production by a firm can be illuminating. Firms combine inputs of land, labor, and capital to produce goods and services desired by consumers. Households, however, combine inputs of time and market goods to produce commodities desired by families. For any good or commodity, the existing technology of the firm or household ultimately determines the maximum amount and quality of output that can be produced with specified quantities of inputs. The household's technology is determined by its *human capital* — its ability, household management skills, and knowledge about how a particular commodity can be produced.

Human capital can only be acquired by investing time in formal or informal education and training that will enable us to function effectively in our complex, changing society. As with any other investment, the returns will not be immediate. They will come in the form of increased earnings in the labor market, increased output from household production, and increased satisfaction from leisure time. Building human capital means increasing the ability of each household member to reach his or her full potential.

Many people believe that the family's most important function is to invest in the human capital of its children by teaching skills, encouraging creativity, promoting positive attitudes, transferring values, and teaching how to manage their own and the family's resources. Much of this process occurs in the schools and on the job; but for infants and young children, the vast majority occurs in the home.

As a result, children are a time-intensive commodity. The time required to produce children of the caliber that families and society demand is also higher than required by other commodities. Significant money expenditures are also required for their food, clothing, shelter, transportation, and college expenses.

Issues

Measuring value added in the home. Because the output of the household production process is not sold, the challenge of assessing its value falls to the researcher. Several approaches have arrived at different and yet surprisingly similar estimates.

In 1978, using 1973 data, Reuben Gronau, an economist at the Hebrew University of Jerusalem, estimated the average value of household production in the United States at over $7,500 (over $20,000 in 1989 dollars). For the average family, he found household production to be equal to 66 percent of total family income. For a family with preschool children, household production can rise to as much as 86 percent of total family income.

This percentage is almost equivalent to family income after taxes — the income actually available for improving family economic well-being. The value of home production was another 20 percent higher in homes where the wife was not employed outside the home.

In 1984, using 1976 data, John Graham and Carole Green, economists at Rutgers University and the University of South Florida, respectively, estimated the average value of household production at $13,000 (over $28,000 in 1989 dollars). To arrive at an estimate of value added, $5,000 ($11,000 in 1989 dollars), we must subtract the estimated value of the goods and services used as inputs for this production.

These figures can also be used to estimate that household production's aggregate value would contribute another 33 percent to the nation's gross national product (GNP). In 1976, using wage rates for activities performed in the home, Janice Peskin, an economist at the Congressional Budget Office, found the aggregate value of the output of U.S. households to be 44 percent of the GNP.

Division of labor by gender. Typically, the wife has been the main household producer, while the husband has worked outside the home. This rigid division of labor by gender between the home and the market arose after the Industrial Revolution as an efficient use of the family's time. Men's earnings were higher than women's in the labor market. Women bore the children and were socialized to be productive in the home.

After World War II, however, real wages increased for all Americans, as did women's education. And recently women's wages have increased faster than men's. Consequently, as stated by Barbara Bergmann, an economist at The American University, women's time has become "too valuable" to spend it all in the home.

In some cases, the most efficient choice for the family — women staying home with their children — left women unprotected in the increasingly likely event of family dissolution. These factors have increased the incentive for women to enter and spend more time in the labor market and less time in household production.

How have families adapted to this change? Some families have simply reduced their household production. Other family members have substituted their time for that of the wife. Data from time-use surveys, however, have not shown large increases in the husband's household production time. The leisure time that has been sacrificed to maintain household production has often been the wife's. Families have also searched for comparable goods and services in the marketplace to substitute for their time. Convenience foods, fast-food restaurants, catalog sales, cleaning services, and nanny services — all have evolved in answer to this need.

Challenges

One of the greatest challenges to emerge from the revolution of women into the labor market is: Who will care for the children? Nanny services are realistic options only for the wealthiest families. Although many families *do* substitute goods and services for some of their own time —for example, day care, babysitting, and music lessons — it is very difficult to substitute for all of it if we want our children to reflect our values, goals, and to develop their human capital potential. Recent data show that more couples are opting to remain childless as a solution to this problem. From the perspective of society as a whole, however, this is not a realistic option.

Thus, we must improve the availability and affordability of quality child care outside the home. Providing maternity leave and parental leave is also an important aspect to caring for our children in an era when few women will devote their lives exclusively to household production.

Policy makers especially need to recognize the importance of value added in the home. If achieving this awareness requires attaching a dollar value, then we need to continue to improve our research methodology and data so that we can produce more precise, reliable estimates.

Another challenge is to help families better manage their resources. Extension home economics makes these skills available to all families on an equal basis, but it cannot and does not reach everyone.

If, as a society, we accept the importance of investing in research and education to improve the management of value-added activities in industry, why not then extend these investments to the home where all would benefit? This investment would certainly cost less than any remedial actions.

Andrea H. Beller, associate professor of family economics, and Sheila Fitzgerald Krein, visiting assistant professor of family economics, both of the School of Human Resources and Family Studies

The Changing Role of Women in Developing Countries

Kathleen Cloud

Almost all value-added production and processing occurs within the household in Africa and Asia's traditional agricultural systems. Food is processed at home. Women and girls spend two to three hours daily hand-pounding millet and corn or threshing and parboiling rice to preserve and improve its cooking quality.

They must also preserve food each year for the "hungry season," the cold or dry period when fresh food is not available. Food preservation techniques include parboiling, sprouting, and fermenting grains; pickling and preserving meats and vegetables in brine; and smoking and drying meats. These valuable techniques seem to have evolved independently in several parts of the world.

A recent study in Pakistan estimates that these and similar domestic activities, if counted, would produce a value-added equivalent of 35 percent of Pakistan's gross national product. Indeed, according to estimates from the International Labor Organization of the United Nations, national income in developing countries would increase between 25 and 50 percent if the economic value of all unpaid household activities were taken into account.

With increased development comes a shift in the types of production and processing that occur in the home. As women are released from the back-breaking work of pounding grain and carrying water, they can concentrate on improving food preparation and cooking. As income increases, consumption of dairy, poultry, and meat products also increases and the nutritional value and variety of the family diet improve.

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↑ Some Indian women prepare rice for storage.

↓ An Indian woman sells vegetables.

© David Recks

Because they are not involved in farm food production, women in towns and cities are able to pursue value-added home activities such as cooking, sewing, crafts, laundry, and cleaning, as well as work outside the household. As schooling becomes more common and more important, time spent in child care also increases steadily for women.

Some economists characterize these increased investments in household health, nutrition, and education as value added to human capital production. Healthy, educated, and energetic men, women, and children can thus be viewed as both a cause and an effect of economic development.

Kathleen Cloud, director, Women in International Development, International Programs and Studies

The "Nation of Tomorrow": A Land-Grant University Experiment

Larry Nucci, Robert Hughes, Jr., Christine M. Todd, Gerald G. Gast, Mark A. Smylie, and Beverly J. McElmurry

As we enter the twentieth century's last decade, America's youth are failing because our society is failing them. Analyses of changes in the behavior of American youth over the past 30 years reveal some alarming trends. Self-destructive behavior, such as suicide and drug abuse, has increased. Destructive behavior that involves others, such as juvenile crime and disorder in schools, has also increased.

A third disturbing trend is a progressive decline in the academic achievement of American students. It is estimated by the U.S. Office of Education that 27 percent of all eighth-graders will not graduate from high school. Fewer than 50 percent of all high school seniors read at levels for moderate success in the work world. These three trends suggest that as a society we must examine our current investments in the children who will be our nation's future.

This crisis has prompted the Kellogg Foundation to issue a bold challenge to land-grant universities. The foundation has proposed creation of university and community partnerships to develop a comprehensive solution through enlightened public policy and community service based on quality research.

In January 1989, University of Illinois President Stanley O. Ikenberry encouraged faculty to respond to this challenge. Larry Nucci and a faculty team developed a project that would address the educational, familial, child development, and health needs of children in some urban Chicago neighborhoods.

The university received a grant from the Kellogg Foundation in September 1989 to initiate the "Nation of Tomorrow" project. Although still in the early stages, the project is a model for how land-grant universities can address the crisis facing American youth.

Project Overview

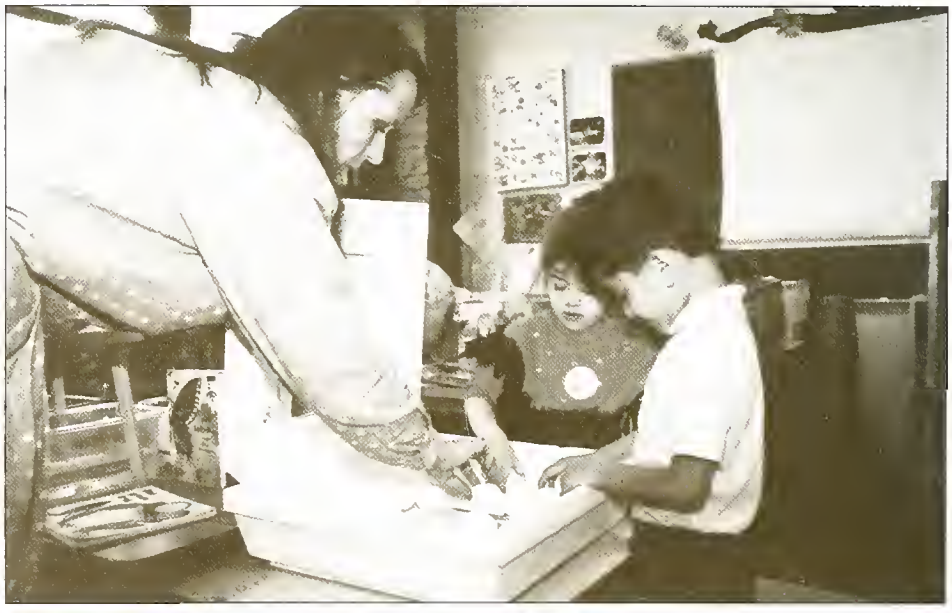
Four Chicago communities comprise the "Nation of Tomorrow." These communities are characterized by extreme poverty, families with many children, predominantly female head of households, and diverse ethnic backgrounds. A target elementary school in each community is the center of activities.

The project has four major objectives.

- To enhance learning opportunities for schoolchildren.
- To enable parents to contribute to their children's development.
- To increase the availability of high-quality child care and youth programs.
- To develop school-based primary health care programs as a part of community resources for the improved health of children.

Several project activities have been designed to achieve these objectives in cooperation with the schools, the families themselves, and the community.

School Enhancement. Efforts are under way to help practicing teachers develop their teaching skills and acquire additional knowledge. There are also plans to enlist school personnel to create a school climate conducive to teacher innovation and professional growth. University faculty and school



↑ A teacher and her students place eggs in an incubator.

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A parent group works together on family well-being.

personnel will identify mutual concerns and collaborate to find and implement solutions through seminars, work groups, and innovative projects.

For example, there has been considerable concern about the literacy of children and the best strategies to develop their reading abilities. Each target school is analyzing this problem to identify possible solutions. As ideas and practices are developed, they will be collected and routinely shared to encourage their widespread dissemination and adoption.

Family Ties. The Family Ties program focuses on three aspects of family well-being: parent education, child care, and youth opportunities. The parent education effort involves creation of a video program by each community based on that community's goals, values, and parenting practices.

Parents, children, community social service providers, clergy, teachers, and other community leaders will work with university faculty to develop programs and delivery strategies that reflect each community's cultural values and effective parenting practices. This planning group will not only identify positive parenting models but also play a central role in designing and producing the actual video program. Upon program completion, parents in the community will be invited for training in how to assist other families in using the program.

Another component of Family Ties will focus on increasing the availability and quality of child care and youth opportunities in the community. Initially, the availability of these opportunities in each community will be documented. When gaps in service are identified, project staff will work with community organizations and parents to fill those gaps. In-service training for staff will also be made available in each community to enhance program quality. Programs for parents will help them locate such services within their own community.

Partners in Health. Improved health care for children and other family members is another project objective. There are three areas of emphasis.

- Implementing a primary health care program that integrates community outreach to ensure assessment, management, and prevention of health problems for schoolchildren and their families.
- Promoting collaboration between community resources for health care of schoolchildren through interagency networks and agreements.
- Assessing economic resources of families and agencies for sustaining effective and comprehensive school-based primary health care services for children. Each community will hire a school nurse and child health advocates from the community to assist children and their families with health issues.

Effective Change

During the past 30 years, many programs have addressed social problems. Along with some important successes, there have also been numerous problems.

For example, we have learned that visiting nurses or specially trained community residents can provide young mothers with information and skills that prevent developmental delays in children. Some intervention efforts, however, may result in feelings of helplessness and dependency. From an analysis of past programs of change, intervention strategies for this project were developed that preserve the successful approaches.

The unique aspect of the "Nation of Tomorrow" project may be *how* the work is conducted rather than the specific activities. The project is based on four general principles that guide the development and implementation of our efforts to address the issues facing youth in an urban environment: competence, partnership, empowerment, and an ecological perspective.

Competence. The project's foundation is that youth, families, and community institutions understand their own needs and have critical knowledge and abilities to meet those needs.

Many efforts at social change, however, take a deficit approach. Rather than assuming competence, a deficit model assumes that those for whom the programs were designed are not competent to address the situation. Thus, "experts" must solve the problems.

Our approach, however, identifies the strengths and resources of each community as a basis for building additional capabilities. For example, we know that some children overcome the disadvantages of poverty and succeed in school. In developing the parent education program, we want to identify strategies

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Even students work together on the project.

developed by parents that have led to the success of those children.

Partnership. Working relationships between the university and the community must be based on mutual respect and cooperation.

Too often, universities and other helping agencies have taken the approach that they have the answer to the problems within the community. While the community may contribute to planning, it was always clear that the helping agency would be the final decision maker.

With the "Nation of Tomorrow" project, however, we are committed to creating genuine partnerships between the university, the public schools, and the community. Established in the proposal's initial draft, these partnerships are also evident in ongoing project management.

Even before development of the proposal, there were meetings with school personnel and community leaders to discern their opinions about major issues confronting youth in their communities and how best to address those issues.

Additionally, an overall project advisory committee of school, community, and university representatives was created to provide basic project direction. Advisory committees were also established in each community to make decisions about plans and activities and to reach a consensus based on joint problem-solving.

Empowerment. The project strives to promote autonomy and self-reliance for youth, family members, and community leaders. The solutions are self-sustaining and not project dependent. For example, the project will not create its own child care program, rather the goal is to facilitate the ongoing efforts of existing community agencies and individuals to expand and increase the quality of child care programs.

Joint problem-solving will be the focus of the work with school personnel, community leaders, agency professionals, and parents. By working with people to maximize their control, we can reduce the feelings of despair and alienation that often prevent effective problem-solving.

Ecological perspective. Effective prevention programs must be intense, comprehensive, and address a broad range of factors that can affect the development of young people.

The "Nation of Tomorrow's" comprehensive ecological perspective includes not only the school environment, but also the family, peer groups, and the community. By working in each of these environments simultaneously, the program can support and strengthen its impact.

Implications

The overall goal of the "Nation of Tomorrow" is to determine how land-grant universities can work with schools and communities to address directly the problems facing American youth. During the next four years, the University of Illinois will examine how schools, families, peers, and community agencies can act upon the principles of competence, partnership, empowerment, and an ecological perspective to effectively improve the lives of the children of today and ultimately the nation of tomorrow.

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**University of Illinois at Chicago*
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Maternal Diet and Child Health

M. Margaret Weigel

The future of families and communities is strongly linked to the health and well-being of our children. Low-birthweight babies of less than 5.5 pounds or premature babies are more likely to die during infancy. These babies also have a higher incidence of other problems — including birth defects, respiratory and other infections, growth and developmental delays, learning and behavioral disorders, and repeated rehospitalizations.

The arrival of babies with these problems often imposes severe emotional, psychological, and social burdens on their families. The economic costs can also range from tens of thousands to hundreds of thousands of dollars.

The costs to the nation are also high. In 1985, the National Research Council estimated that the total cost associated with caring for low-birthweight babies approaches $200 million a year. These babies comprise 11.5 percent of all infants born in the United States. The data suggest that reduction of only 2 percent in the low-birthweight rate would represent a savings of $28 million a year — even when the increased cost of providing adequate prenatal care for all pregnant women is taken into account.

Many factors can affect birthweight and other infant outcomes. But good maternal diet and overall nutritional status appear to be the most important prenatal care strategies that reduce risk of poor pregnancy outcome.

Pregnant women have increased needs for water, energy, protein, and several vitamins and minerals — including some B vitamins (especially folacin), vitamin C, calcium, iron, and zinc. Unfortunately, women do not always select foods that would give them the best nutrition for their dollar.

University of Illinois researchers are currently studying how a woman's age, cultural background, educational level, socioeconomic status, family residence patterns, and other factors can affect her dietary decision-making during pregnancy. They are also examining the effect of specific dietary nutrients, especially minerals, in maternal and infant outcomes.

Pregnancy-induced hypertension or high blood pressure, for example, affects one of every ten pregnancies in the United States. This serious disease is associated with increased maternal and infant mortality, preterm delivery, and low birthweight. The symptoms, however, cannot normally be treated with conventional antihypertensive drugs because their side effects can harm the mother and the fetus. In severe cases, physicians may induce premature delivery.

Investigators at the University of Illinois and their colleagues at the Universidad Central del Ecuador have been conducting studies to determine if adding two extra grams of calcium per day to the mother's diet can reduce her risk for pregnancy-induced hypertension and improve her chances for delivery of a healthier baby. It appears that calcium supplementation may be a safe, cost-effective way to reduce the risk of this disease in high-risk mothers.

In general, researchers have found that well-nourished mothers who eat a diverse, balanced diet and who gain appropriate weight during pregnancy have a greater chance of delivering heavier, healthier full-term infants. Even mothers whose dietary habits and nutritional status were poor before conceiving can greatly increase their probability of delivery of normal infants by eating well and gaining appropriate weight during pregnancy.

M. Margaret Weigel, assistant professor of community nutrition, Division of Foods and Nutrition, School of Human Resources and Family Studies

Education of Young Children Begins at Home

Judy S. DeLoache, Leann L. Birch, and Laurie F. Kramer

The word "education" typically evokes images of classrooms, desks, chalkboards, and apples for the teacher. Well before children start formal schooling, however, they learn from their first teachers, their families. At the University of Illinois, some researchers from the Division of Human Development and Family Studies study the learning that occurs in the American home during picturebook reading, family mealtimes, and sibling interactions.

Picturebooks. Picturebook reading teaches young children vocabulary and concepts. Through books, very young children learn about kings and queens, ocean liners and spaceships, and dinosaurs and dragons — people and things with which they have no direct experience.

Children also learn about books. At first they discover that pictures are representations or symbols for other things. Eventually, children understand that the wiggly marks on the page are also symbols

for sounds that are in turn symbols for meaning. Thus, literacy begins on the parent's lap.

When reading picturebooks to their toddlers, parents often have explicit, well-articulated goals. Most middle-class parents report that they want to instill a love of books and learning that they hope will last throughout their child's life.

Research by DeLoache shows that during picturebook reading, mothers use various strategies to direct the child's attention, to communicate information, and to elicit a display of the child's knowledge.

With very young children the interaction mostly involves labeling the pictures and providing some information about them. For example, "See the doggy. The doggy says, 'woof woof.'"

Questions for slightly older children are intended to get them to label and tell about the picture. For example, "What's that? What does the doggy say?"

As young children become more verbal and cognitively sophisticated, mothers communicate increasingly complex information and demand more. For example, a child may be asked to describe how something in a book relates to an actual experience.

Mothers thus provide a form of "cognitive scaffolding" that supports their child's maximum participation. Each child is constantly challenged at a level that assures success. This moderate degree of challenge optimally facilitates the child's cognitive development.

Mealtime. Important learning also occurs everyday at the family dinner table. Birch's research reveals that children learn what to eat, which foods to like and dislike, and when to start and stop eating.

Children's early eating experiences are crucial in forming food acceptance patterns. Although most children have an innate liking for sweetness and a dislike of sour, bitter tastes, other food acceptance patterns are learned. And parents usually structure these experiences in the home.

In general, children prefer familiar foods and do not quickly accept new ones. Providing repeated opportunities to sample new foods, however, increases the chance that children will like and accept a variety of foods — a pattern essential for adequate nutrition.

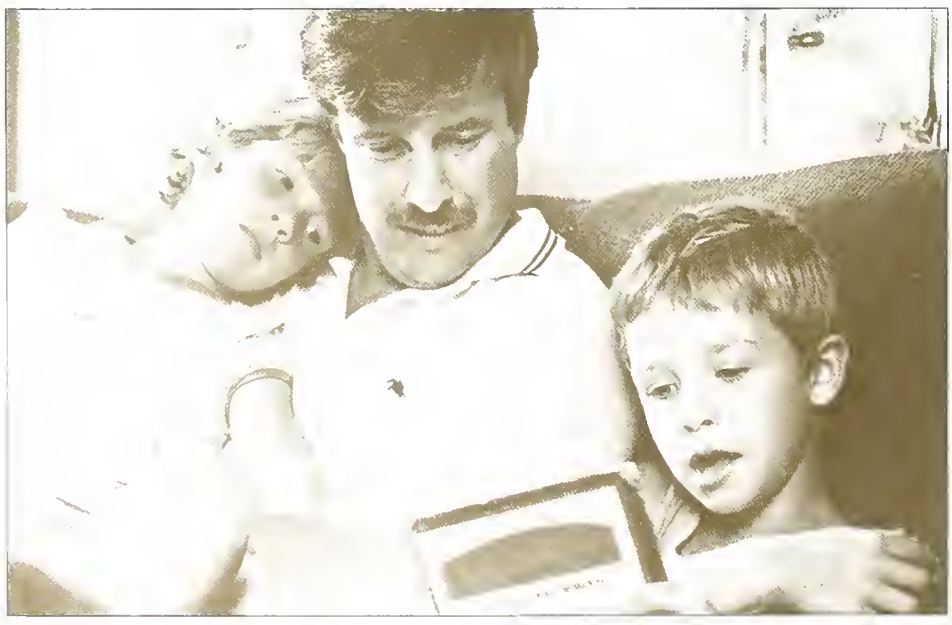
Unfortunately, this acceptance is not instantaneous and may require eight to ten experiences with a new food. In addition to structuring opportunities to try new foods, parents and siblings may also serve as models to encourage young children to sample new foods.

Parents typically want their children to eat primarily healthful foods. Many parents limit their own intake of fats, sugar, and salt and may attempt to impose such limits on their child's diet. But some practices that parents use to get their child to eat healthful foods may actually teach unhealthful eating patterns.

For example, many parents restrict their child's intake of sweets and savory snacks but then use these same foods as rewards, pacifiers, or treats. In the United States, sweets are often served at the end of a meal, and sweets and high-fat foods are part of our holiday meals and special treats. This association of foods with festive family social occasions may increase a child's liking for these foods. But if parents coerce their child to eat "healthy" but disliked foods, such foods may become even more strongly disliked. Coercive feeding techniques may enhance a liking for foods high in sugar and fat and foster a dislike for healthful foods.

Siblings. Young children also learn from older siblings. One study by Kramer followed a group of preschool children for several years from the birth of a younger sibling. These observations showed that the sibling relationship includes much teaching and learning.

For example, children were often observed teaching younger siblings a game, how to fasten a zipper, or their ABCs. Younger children were remarkable imitators of older siblings' behaviors. As they approached school age, older siblings often took more active roles as tutors or coaches to younger brothers and sisters. Younger siblings thus benefited from the older children's knowledge and experience. The older siblings also experienced the satisfaction and positive self-esteem that come from being effective teachers and nurturers.



Judy S. DeLoache, professor of child development and psychology; Leann L. Birch, professor of human development; and Laurie F. Kramer, assistant professor of applied family studies, all of the Division of Human Development and Family Studies

Family Diversity in the United States

Sharon Y. Nickols, Linda Asmussen, and James D. Oliver

Over the past 25 years, there have been tremendous changes in the family as a social institution and in the definition of the U.S. family. Although the United States has always been a pluralistic society, family diversity was recognized only recently. Previously, all family types were judged by a middle-class Euro-American model of the "ideal" family.

Today's contemporary family, however, reflects a multiplicity of living arrangements, gender roles, and relationships. To understand and work with modern families, we need to recognize this diversity. Each family has the potential to contribute to individual development and to the broader society. But rapid changes have made the family more vulnerable both economically and socially.

This article summarizes some of the major trends in U.S. families in recent years. We have drawn upon U.S. Census data and other sources for the statistics and trends reported here. We also identify policy implications that may affect the family's ability to add value.

Diversity of Family Structure

Typical household. In 1971, 81 percent of us lived in households that included a married couple. But only 73 percent of us live in such a household today.

To illustrate, let a hypothetical block of ten households correspond to the total distribution of U.S. household types (see figure). Six households — three of which have children present — are maintained by married couples. Two other households are maintained by persons living alone. One household is maintained by a single parent, one by other combinations of persons living together.

In 1986, married-couple families accounted for 83.4 percent of white families, 70.8 percent of Hispanic families, and 52.7 percent of African-American families. One-parent families, however, comprised 16.7 percent of white families, 29.1 percent of Hispanic families, and 47.2 percent of African-American families in the United States.

Divorce. Divorce affects the lives of approximately 2 million adults and more than 1 million children in the United States each year. In Illinois, the divorce rate in 1985 was 4.2 per 1,000 population, slightly less than the national rate of 5.0 per 1,000 population.

After a sharp increase between 1965 and 1980, the divorce rate in recent years has stabilized. Slightly more than one-half of all new marriages are expected to end in divorce. Most divorces occur after

Household types by distribution in the U.S. population

seven to eight years of marriage — a pattern that is similar for white, Hispanic, and African-American populations.

Remarriage. Current statistics, however, indicate declining rates of remarriage. Five of six divorced men and three of four divorced women eventually will remarry if present trends continue.

Remarriage usually occurs within the first two to three years after divorce. Comparing divorce and remarriage rates for women by race indicates that there is variation among racial groups (see table).

Divorce and Remarriage Rates for Women*

	Divorce rate for first marriages	Remarriage rate after divorce
	percent	
African-American	30.6	45.7
White	26.7	64.3
Hispanic	19.5	55.1

* Data for women age 20 to 54 years of age in 1985.

Children and Their Families

Single-parent families. In 1981, approximately 20 percent of children below the age of 18 were living with one parent. The 1990 Census is expected to reveal an increase of these children — likely more than one-fourth of all households (26.5 percent). On the average, children spend six years in a single-parent family created by divorce.

Stepfamilies. Approximately one-third of all children born in the early 1980s will live with a stepparent during some part of their childhood. In 1987, there were approximately 11 million remarried families. There were 4.3 million stepfamilies (families that include children at home under the age of 18 who were born before the remarriage occurred). Stepfamilies comprised 6.7 percent of all families and 17.4 percent of married-couple families with children at home under the age of 18.

Pregnancy and birth. By age 19, one-fourth of all females have a baby. Eighty percent of these mothers are not married. The proportion of children born to unmarried mothers increased from 5 percent in 1960 to 19.2 percent in 1987 or 12 percent of white births and 55 percent of African-American births.

Illinois ranks among the five states with the highest incidence of infant mortality and low birthweight among the nonwhite population. For every 1,000 live births in Illinois, 12.4 infants die before the age of one year. One grim statement summarizes these dismal statistics — an African-American baby born in Chicago is more likely to die in the first year of life than a baby born in Costa Rica.

Changes in Gender Roles and Economic Status

Working mothers. A majority of married-couple families, 60 percent, have dual incomes. Women with young children are the fastest growing segment of women in the work force. In 1987, 50.8 percent of women who gave birth in the preceding twelve months were working. Employed mothers with preschool-age children numbered over 8 million nationally in the first quarter of 1990.

On the average, employed mothers' earnings in married-couple families with children are 41.3 percent of total family earnings, a significant portion. Thus, families have come to depend upon the earnings of both husband and wife.

Children in poverty. Despite modest increases in median family income in the mid-1980s, recent data on household income reveal that certain groups are losing ground. In 1987, one in five children lived in households with incomes below the poverty level.

The 1990 Census is expected to show that 25 percent of the nation's children are living in households with incomes below the poverty level. Among white children, one in every six is poor compared to more than one in every three Hispanic children and nearly one in every two African-American children.

Children are especially vulnerable to economic insecurity if they live in a household with a female single parent. Median family income of households headed by women is considerably less than half that of families headed by married couples or by men. Between 1979 and 1986, the number of jobholders who fell below the poverty level increased from 8.5 to 8.9 million nationally.

"Safety net" programs are reaching fewer eligible people today. For example, the Food Stamp program fails to reach one-third of those who are eligible; the Women, Infants, and Children (WIC) nutrition program serves less than 50 percent of high-risk, low-income women and children; and Aid to Families with Dependent Children (AFDC) went to only 60 percent of children in poverty in 1986, compared to 72 percent in 1979.

Implications for Family Policy in the 1990s

Recent trends in family characteristics reflect thousands of individual decisions in response to changing social and economic conditions. The cumulative effect of these decisions and other sociodemographic factors have markedly changed the profile of the U.S. family.

As families and personal relationships change, families will become even more diverse. Because families are process-oriented, they are constantly adopting new features and adapting to changes in the economy and governmental policies.

Policies and programs that once worked well may need adjusting in new situations. Policies and programs that work well with one population segment may need redesign to meet the concerns and needs of other populations. No one should know this better than the people of Illinois with our diverse geography, economy, and population distribution.

As the forces of change remake the economy, increasing opportunities in some areas and decreasing opportunities in others, some families can provide only the barest necessities for themselves.

Of particular concern for the future is the growing number of children living in households below the poverty level. Because they can do little more than meet daily survival needs, these households are severely hampered in their ability to add value to their children's lives.

Greater economic security can be achieved by several methods, some of which are discussed elsewhere in this issue of *Illinois Research*. To meet some of the critical challenges facing the family during this decade, U.S. policies and programs should focus on the economic well-being of single-parent families.

Specifically, some of the key issues that would add value to these families relate to

- Availability of affordable housing.
- Access to quality, affordable health and child care.
- Education and career training.
- Creation of job opportunities that provide adequate income and advancement.

Census data and large-scale surveys conducted by government agencies can provide an overview of trends in family composition and economic status. In-depth studies are needed to discover the intricacies of family decision making and relationships that provide value-added models of interaction.

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What Has Happened to the "Old Folks at Home"?

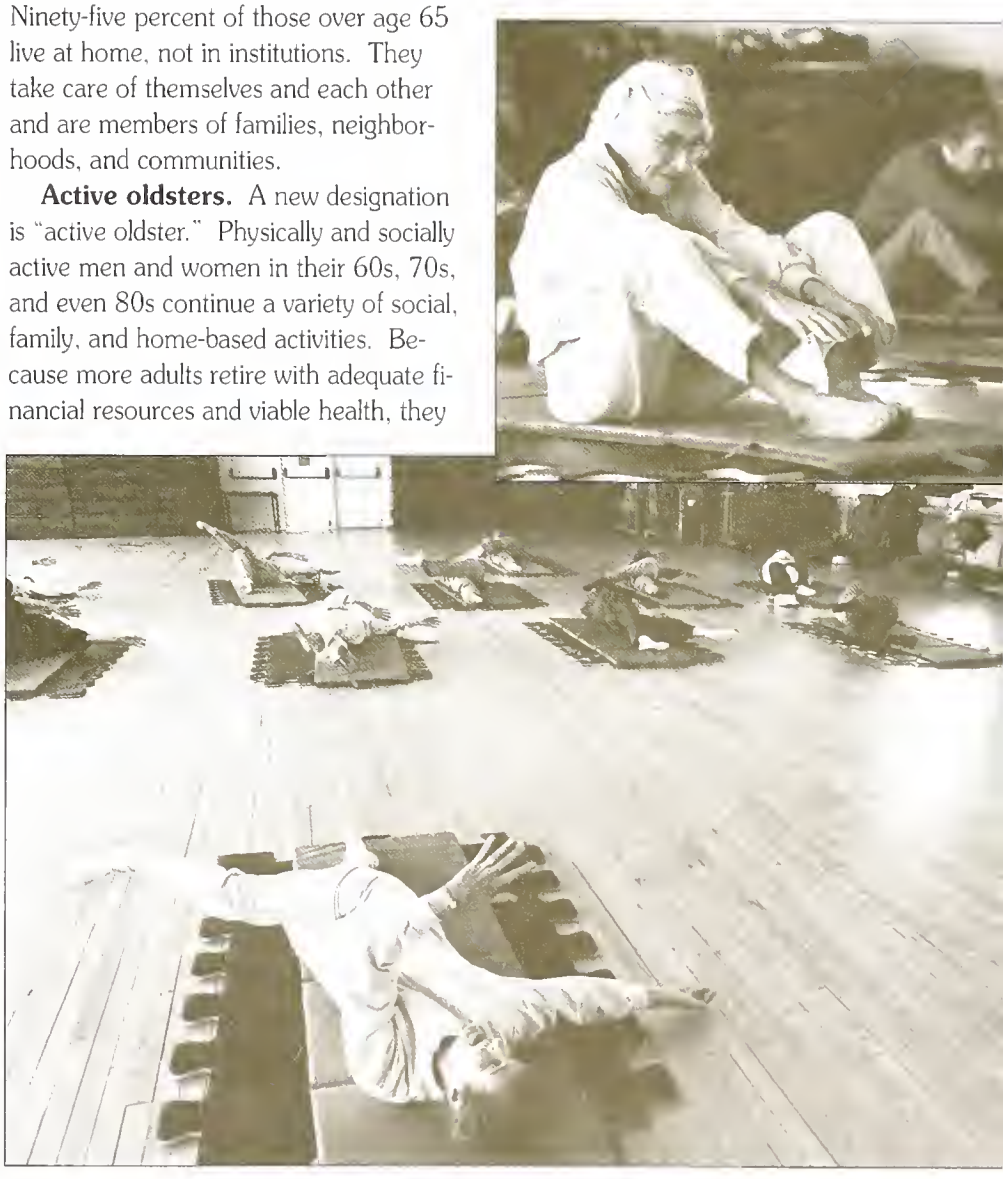
John R. Kelly

The stereotype of aging is primarily negative and untrue: Youth is supreme, but from then on it's downhill all the way. The advertising media, recognizing "old folks" as a significant market, increasingly portrays them as active and vital. Ninety-five percent of those over age 65 live at home, not in institutions. They take care of themselves and each other and are members of families, neighborhoods, and communities.

Active oldsters. A new designation is "active oldster." Physically and socially active men and women in their 60s, 70s, and even 80s continue a variety of social, family, and home-based activities. Because more adults retire with adequate financial resources and viable health, they are able to build lives at least as satisfying as their preceding years.

A study I completed a year ago of recent retirees of a food-processing plant in Champaign, Illinois, painted a common picture of retirement. Most of those interviewed had retired within the past three years. They were getting on as well or better than they had expected. They had modest but adequate incomes and reasonable health.

These men and women had held routine jobs, had not been to college, were glad to be free of their work schedules, and were enjoying retirement. Their social worlds revolved around their families. Most of their activities were accessible,



↑ Pat Larson, yoga instructor, (bottom) leads a class at the Urbana Park District's Thornburn Center.

low cost, and home centered — activities that they had pursued before retirement and new ones that required additional time. New routines included a core of companions and activities punctuated by occasional special events and travel. Their lives were meaningful and satisfying. The only exceptions were those with health limitations or those who had recently lost a significant family member.

During retirement our need for challenge and accomplishment continues. There is no substitute for day-to-day sharing with others and engaging in meaningful activity. The result is healthier, happier, and less depressed old people, who are more satisfied with their lives and themselves.

Remember, these people have been productive. They have reared families, developed communities, produced goods and services, performed research, supported the government with their actions and their taxes, and, in general, contributed to society. They have every right to believe that they have done their share. When they expect to be supported in a reasonable quality of life, they are not being greedy but merely stating their right to a return on their life investment.

The "active old" are often the volunteers who operate referral centers, deliver meals and books to the homebound, and keep much of the community service structure going. They not only drive and care for grandchildren, but they are also frequently the caregivers for the frail elderly.

When they reach age 65, over half of American adults now have a parent living. They go on helping, sharing, and caring — often with greater intensity now that they are no longer bound to an employment timetable. And those who have a sense of being of value, of doing what is worthwhile for themselves and others, experience no decline in self-esteem. They know daily that they have been and are still productive.

Transition into frailty. Of course, this involvement does not go on forever. A higher proportion of older people will live to become relatively dependent. About half of those age 80 and over will spend some time in a care facility before they die. At any given time, however, a much larger proportion will be living at home. Some will share a residence; more, usually women, will live alone.

For many, this transition into frailty will be a gradual one. Geographically and socially, the range of activities becomes more constricted, more home-centered. Poverty and illness can accelerate this trend. Activities that require strenuous travel are dropped, and ones that can be carried out at or near home take on great significance. Although former companions and engagements are still important, it is just no longer possible to do everything.

Good news. So, what's the good news for this transitional period?

- Most communities now provide various services to sustain and enrich the lives of older people.
- The home itself is becoming an increasingly rich, stimulating environment. Cable TV and VCRs offer entertainment, education, information, debate, and stimulation. Fiber-optic cable will enhance these opportunities even more. Libraries may even add video selections to their book delivery services.
- The enriched home environment can be managed and personalized. It can become a social center for family, friends, and neighbors to meet.

Implications. Affordable and well-planned housing for older people must become a priority along with health care. There is no substitute for caring people who make it a priority to form social networks around those who are increasingly homebound. Even in their homes, older people continue to contribute their wisdom and experience to those who are willing to listen and care. And those who receive care can go on sharing their love.

John R. Kelly, professor of leisure studies and director, Office of Gerontology and Aging Studies

Remodeling This Old House

Joseph L. Wysocki

Americans are keenly interested in improving their older homes to include the amenities of newer homes. Growth in this segment of the construction market is expected to continue. Annual remodeling expenditures are expected to reach $289 billion by the year 2000, almost three times the 1990 projection.

The remodeling boom is a response to many factors. Vast increases in housing prices, high interest rates on new mortgages, and the costs associated with selling, buying, and moving — all have compelled consumers to stay in their present homes and remodel. In rural areas, especially for farm households, moving is not a realistic option. Remodeling, however, is an alternative, more affordable way to move up in the housing market. Many homeowners are using sweat equity to cut costs even further by doing some or all of the remodeling themselves.

The Study

In the late 1980s, housing researchers in the North Central states, supported by their respective agricultural experiment stations, analyzed past home remodeling decisions and future remodeling plans of 500 rural households. Families in Illinois, Iowa, Minnesota, Missouri, Nebraska, and Wisconsin were surveyed. Of these families, 52 percent had remodeled their homes during the past five years.

The survey indicated that the remodelers were between 30 and 49 years old, married with three- to four-person households, and had annual incomes over $30,000. These baby boomers, born between 1946 and 1964, comprise about one-third of the current U.S. population.

Remodeling changes. Table 1 presents the distribution of the various changes. Both interior and exterior appearance changes were the most popular,

Table 1.
Home Remodeling by Rural North Central Households

Remodeling Project	*Percent*
• Changed interior appearance	59
• Changed exterior appearance	58
• Changed mechanical system	51
• Improved energy efficiency	40
• Added outdoor living space or storage space	34
• Ceased use of existing space	28
• Converted unfinished space	17
• Added indoor living space	10
• Changed use of existing space	9

Table 2.
Home Remodeling Planned within the Next Five Years by Rural North Central Regional Households

Remodeling Project	*Percent*
• Improve interior appearance	28
• Improve exterior appearance	24
• Add energy conservation features	14
• Change use or function of existing space	10
• Add outdoor living space	9
• Change mechanical system	8
• Convert unfinished space	8
• Add interior space	6

59 and 58 percent, respectively. Kitchen and bathroom remodelings dominated interior changes, 43 and 38 percent, respectively. Exterior changes included new roofs (29 percent), siding (23 percent), windows (25 percent), and landscaping (29 percent).

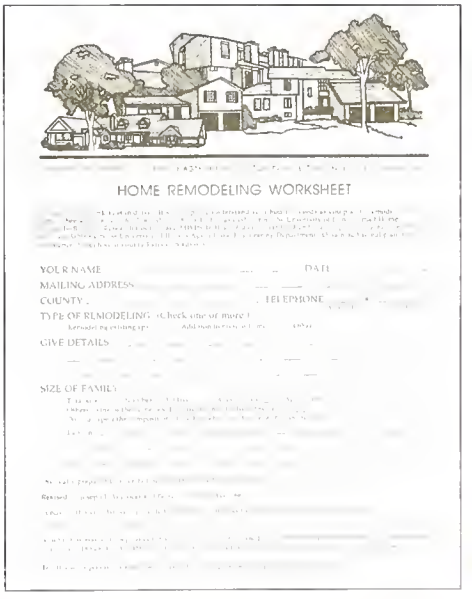
Fifty-one percent of the households surveyed changed their home's mechanical system. Of these changes, 64 percent were to home heating systems. Forty percent of the households improved their home's energy efficiency. Significantly fewer households had ceased use of space — closed off a room or an entire floor — added indoor living space, or converted unfinished space. The most frequent change to existing space decreased the sleeping area and increased recreational space.

Outdoor living space was added three times as often as indoor living space, 34 and 10 percent, respectively. Fifty-four percent of the sample added decks.

The future. About 30 percent of the households surveyed plan to remodel in the next five years. The future plans of the total sample (Table 2) seem consistent with the changes indicated in Table 1. Improving the interior and exterior appearance were the top remodeling changes planned, 28 and 24 percent, respectively, followed by adding energy conservation features, 14 percent. A small percent of respondents, 10 percent, planned to change existing space. Even fewer planned to convert unfinished space or add indoor living space, 8 and 6 percent, respectively.

Program Response

Total housing costs, the largest household budget item, encompass over 33 1/3 percent of a household's income and 50 percent or more of the income for elderly and limited-resource households. Housing affordability, the major housing issue today, is the focus of extensive programs in Illinois. One major component of these programs is to assist households — especially rural, elderly, and limited-resource households — with decisions related to remodeling their homes to best suit their needs and resources.


HOME REMODELING WORKSHEET

The findings of this survey support the popularity of remodeling as a viable, affordable housing alternative. The findings also suggest kitchen and bathroom remodeling projects as possible areas of program emphasis.

More than just a place to plan and prepare meals, the kitchen in many households is the center of activity. It functions as an office, a dining area, and a place for the children to do their homework.

The popularity of bathroom remodeling can be attributed to our growing interest in health and fitness. Many homeowners have remodeled their bathrooms to accommodate a sauna and exercise equipment. Others have incorporated this equipment in large master bedrooms or a separate room.

Several University of Illinois publications can help consumers plan their remodeling projects. The bibliography in this issue includes several of these sources. Remodeling workshops are also offered periodically through county Extension offices.

Joseph L. Wysocki, assistant professor and Extension housing specialist, School of Human Resources and Family Studies

Money Matters: Family Financial Management Makes a Difference

Vicki Schram Fitzsimmons

In the summer of 1968, Susan and Don Brown* were married in the central-Illinois city of Peoria. Phyllis and Bob Thompson* were married about 60 miles to the southeast, in Decatur. Both couples were in their early 20s and were high school graduates with annual incomes of approximately $15,000. Don and Bob were employed in semiskilled occupations; Susan and Phyllis had clerical jobs. Neither couple owned a home, and their net worth was very similar.

As is the case with many newlyweds, the Browns and the Thompsons were faced with setting up a household with few resources. During their first years of marriage, both couples had to make some important decisions about something altogether new and challenging — managing *family* finances.

Although the couples began married life in very similar circumstances, by 1980, the year of their twelfth wedding anniversaries, their financial positions were considerably different. By then, both couples had increased their incomes to the same level, about $26,000. But the Thompson household still had two income earners, while Don had become the only income earner for the Browns. The Thompsons needed two incomes to match what Don Brown earned alone. This would appear to have given the Browns an edge in accumulating more wealth because Susan had time to produce nonmarket income in the home, such as growing and preserving vegetables, sewing clothes for the family, and planning and preparing meals to avoid the expense of eating out. All these activities could have helped to stretch the Browns' income. Thus, more money could have been available for saving. This, however, was not the case.

Even though their incomes were the same, the two families' net worths (assets minus liabilities) were markedly different. In fact, excluding their personal residence, the Browns in 1980 had $0 net worth, while the Thompsons had $14,500.

Although both couples were homeowners, insufficient information about the value of their homes made a comparison difficult. Asset and liability information on other components of the couples' net worths (for example, the value of automobiles and other durable goods, savings, and investments) was used to calculate net worth exclusive of personal residence. This value is an important indicator of available resources, savings for goals other than buying a home, and ability to cope with financial adversity.

What Made the Difference?

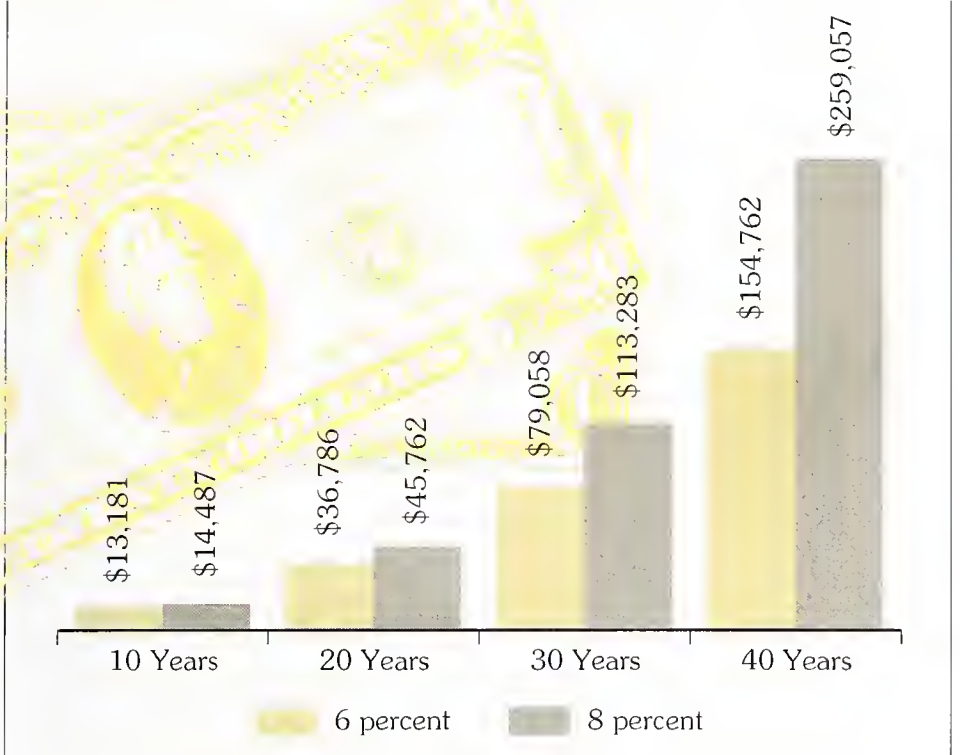
To gain insight into family finances, University of Illinois researchers conducted a study of about 200 newlywed couples in Peoria and Decatur from 1968 to 1981. The Browns and the Thompsons were among the families studied, and they represent the average respondents in the survey.

The two couples' saving and spending patterns illustrate the situation for many young families. Given the same initial circumstances, some do well financially while others do not. For some families, education makes the difference; those with higher education usually earn higher incomes. Neither the Browns nor the Thompsons continued their education beyond high school. Number of children can make a difference. The more children a family has, the more stress is put on family income. Both couples had two children, so this factor did not account for the difference either. Death of one spouse or divorce can have a debilitating effect on family finances, but neither occurred for the couples under study. Other factors affecting a family's financial situation include inheritance, disability, and job layoff. (These factors may have accounted for some of the difference in net worth for the Browns and Thompsons, but information was not collected on these factors.)

Attitudes about spending and saving can indicate subsequent financial management behavior. The University of Illinois survey data show that the Browns and Thompsons had different attitudes about finances. As newlyweds, the Browns did not plan to save any particular amount each month, while the Thompsons did.

The best way to have savings is to treat it as a regular budget category and to save a set amount each month. Regular savings over a long time is the key to accumulating money for a secure retirement as well as interim goals. Saving over a long period can result in much greater total savings, largely due to

* *Not their real names.*



Amounts attained by saving $1,000 each year after 10, 20, 30, and 40 years at interest rates of 6 and 8 percent.

Source: Lang, Larry R., and Gillespie, Thomas H. 1984. *Strategy for Personal Finance.* (3d ed.). New York: McGraw-Hill.

regular saving and compounding interest (see figure).

The Browns got into trouble by deciding early on to save whatever was left at the end of the month. Financial educators cite this as poor financial management. When a family saves whatever is left over, the amount tends to be irregular and small, if anything at all. Unfortunately, people tend to spend all they have readily available.

By contrast, the Thompsons said they would try to keep expenditures down so they could save. Saving often means lowering consumption of goods and services so money is available to save. Changes can be made in quantity, quality, or variety of goods and services, which can free up dollars for saving without seriously lowering the family's standard of living. For example, choosing private-label products over national brands can result in significant savings. Choosing inexpensive hobbies can result in savings; more expensive hobbies can be pursued later in life, when income is greater.

Financial Management: A Major Task

Financial management, one of the major tasks families have, varies by stage in the family life cycle. Newlyweds need to sort out how to handle finances — who will pay the bills, how financial decisions will be made, and so on. Much knowledge about housing, insurance, investments, taxes, and durable purchases needs to be acquired and used to make appropriate financial decisions at any stage of the family life cycle.

The specific kinds of knowledge will vary. For example, young couples may need to know how to shop for rental housing; middle-year families may need to focus on home ownership and its related costs; elderly families may benefit most by concentrating on how to use home equity for retirement income.

Each family may require large sums of money to fund a home, to raise children and pay for their education, to buy durable goods, and to secure retirement income at the very least. To accumulate these large sums, families must make spending and saving decisions to make the most of their resources. As income and expenditures change, financial management continues to play an important role.

Families can learn about financial management through a variety of methods. Reading about the topic is an easy way to get started (see bibliography on page 25). Attending financial management classes and seminars and consulting with financial planners and educators are also helpful.

Financial management skills are developed by applying accumulated knowledge and managing finances. Choosing types and amounts of insurance appropriate for one's particular family and financial situation is one example. Often, more insurance can be obtained for the same amount of money by choosing appropriate life, health, property, liability, and disability insurance.

For example, one can acquire more protection for the same amount of money by purchasing term rather than whole-life or universal insurance. This is one way families with few resources can get the most life insurance protection possible. Families often need more liability protection than they think they can afford. At the same time, they usually have a low deductible of $50 or $100 on their property insurance. Raising the deductible (to an amount still within emergency reserves) results in a lower premium. The savings can be used to purchase higher liability coverage.

Relating Financial Management to Value Added in the Home

Family financial management affects more than just the pocketbook. If done correctly, it can improve a family's net worth and provide greater command over goods and services. Sound financial management enables a family to improve economic well-being. But it also adds a greater feeling of control, an important factor in dealing with economic adversity.

Another benefit is improved family relationships. Good communication and development of mutual goals are important aspects of successful financial management, and these enhance both spousal and parent-child relationships.

Quantifying the value added from family financial management is somewhat difficult. But one way to get some idea of its effect, is to speculate on the change in personal savings. Assuming that people do not save regularly, and do not spend effectively, improved financial management could result in increased savings.

Given the low personal savings rate in this country (4 percent in 1986, compared to 12.5 percent in West Germany and 21 percent in Japan), an increased savings rate could have a profound impact on the overall economy.

Before calculating the possible change in overall personal savings, we need to know whether people already save regularly. The answer is a resounding *no*. In 1989, the author and another University of Illinois researcher, Jeanne Hafstrom, surveyed rural households in Illinois.

When asked how often they saved regularly for goods, only 28 percent of the respondents said they did so "most of the time." The remaining 70 percent did not save at all or did so on an irregular basis.

Further, almost 50 percent of the respondents were dissatisfied with the amount of money they were able to save, and 18 percent had mixed feelings. Given this information, it seems likely that savings could be increased through improved financial management.

An individual or a family can use a future value table (like the one shown) to calculate the effect of increased monthly savings on total accumulated savings. For example, saving $100 a month for 20 years and consistently earning 8 percent interest would result in $54,912. By saving just $10 more each month, the value in 20 years would be $60,403, a difference of almost $5,500.

On a national level, personal savings amounted to $203.7 billion in mid-1989. If, through better financial management, people could increase their savings by just 1 percent, the aggregate increase would be $2.37 billion for the nation. A 10 percent increase would yield $20.37 billion. Further, an increase in this kind of nationwide saving would also increase national income and employment. Savings are invested in the production of goods and services, which results in more jobs for people who then have more money to spend and save. All of this has the potential to expand the economy and increase national income.

Thus, the value added by personal financial management has an enormous potential for improving the economic well-being of families and for increasing national wealth. Financial management education throughout the family life cycle is an important step in helping families and the nation to realize this potential.

Vicki Schram Fitzsimmons, associate professor of family and consumer economics, and graduate programs coordinator of Division of Consumer Sciences, School of Human Resources and Family Studies

Future Value of Savings of $1 per Year at Selected Interest Rates

Year	6%	7%	8%	9%	10%	12%
1	1.000	1.000	1.000	1.000	1.000	1.000
2	2.060	2.070	2.080	2.090	2.100	2.120
3	3.184	3.215	3.246	3.278	3.310	3.374
4	4.375	4.440	4.506	4.573	4.641	4.779
5	5.637	5.751	5.867	5.985	6.105	6.353
6	6.975	7.153	7.336	7.523	7.716	8.115
7	8.394	8.654	8.923	9.200	9.487	10.09
8	9.897	10.26	10.64	11.03	11.44	12.30
9	11.49	11.98	12.49	13.02	13.58	14.78
10	13.18	13.82	14.49	15.19	15.94	17.55
11	14.97	15.78	16.65	17.56	18.53	20.65
12	16.87	17.89	18.98	20.14	21.38	24.13
13	18.88	20.14	21.50	22.95	24.52	28.03
14	21.02	22.55	24.21	26.02	27.98	32.39
15	23.28	25.13	27.15	29.36	31.77	37.28
16	25.67	27.89	30.32	33.00	35.95	42.75
17	28.21	30.84	33.75	36.97	40.54	48.88
18	30.91	34.00	37.45	41.30	45.60	55.75
19	33.76	37.38	41.45	46.02	51.16	63.44
20	36.79	41.00	45.76	51.16	57.28	72.05

Source: Garman, E. Thomas, and Raymond E. Forgue. 1988. *Personal Finance* (2d ed.). Boston: Houghton Mifflin Co.

NOTE: $FV = A_n \times F$
FV = *future value*
A_n = *amount* (savings) for *n* periods
F = *factor* of future value (given a certain interest and *n*)

Illinois Model Farm and Family Improvement Project

MaryAnn Paynter and Duane E. Erickson

"We've seen some real changes on our farm. We were in trouble financially. By setting goals...and working a little harder, we were able to [improve] that situation a lot," says Kent Hildebrand, a Bureau County farmer. His wife Karen works on the farm and also has a full-time job. Their three children are college graduates. The Hildebrands wanted to get out of debt and plan for retirement.

The program. The Hildebrands are one of six farm families participating in the Bureau County Farm and Home Improvement Project. With the help of the five-year program, the Hildebrands were able to refinance their farm at a more favorable interest rate. The program developed by an interdisciplinary team of Extension specialists and advisers was designed to strengthen the management skills of farm families.

The program also supports two Cooperative Extension Service National Initiatives. The family and economic well-being initiative includes the critical issues of providing help during family disruption and dislocation and of providing family financial stability. The agriculture initiative emphasizes farm competitiveness and profitability.

Project objectives were approved by the county Extension Councils. Each of six competitively chosen families would

- Learn to apply research findings to business and family management.
- Strengthen record-keeping and financial management skills: enroll in the Farm Business Farm Management (FBFM) program and develop an annual comparative farm business analysis.
- Develop farm production plans — including soil testing, crop and fertility planning, and using other innovative methods and technologies.
- Identify preferences and determine priorities for farm and family goals.
- Make a five-year management plan using individual, family, and community resources to accomplish goals.
- Participate in group demonstrations to share information and practices with the community.

All project families agreed to videotape interviews. The edited video, "The Future is Ours: Managing Farm Family Goals," documents the positive attitudes of these families toward program involvement. The video can also be used to motivate other farm families to participate in goal-oriented management.

Results. The six families' financial analyses indicate increased growth each year. Farm record summaries for program participants suggest net returns above the average of comparable FBFM cooperators in Illinois. After three years of the program, soil tests obtained for each participating farm revealed increased pH, phosphorus, and potassium test readings. Improved family and economic well-being resulted from families adopting fertilizer recommendations, financial planning, farm and family goal-setting, and estate planning.

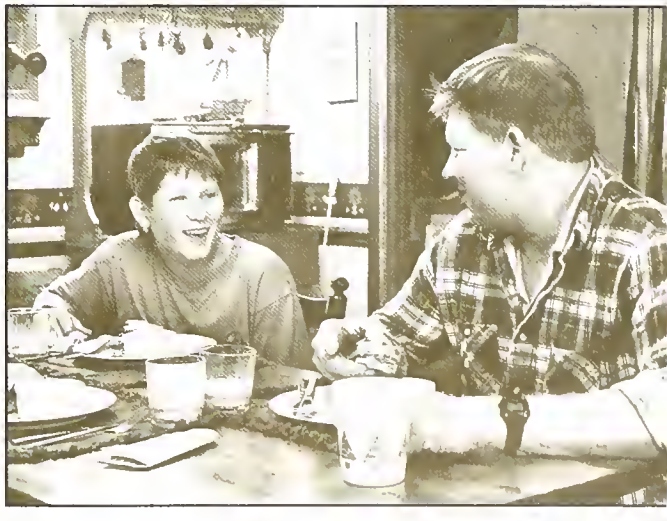
Specific practices adopted by program participants include changes in record-keeping systems, revisions in insurance programs, improvements in financial management techniques, increased decision-making to set priorities and to make plans, and identification of goals to provide direction for progress. The families believe that goal-oriented management requires communication and commitment, that goal revision is necessary when a family's situation changes, that farm and family goals are intertwined, and that written goals are more effective than verbal ones.

The project reflects the spirit of its participants. Family members in the program share equally in the discussion and implementation of family and business goals. Agriculture and home economics resources are also available from county and state Extension staff. The families then make decisions based on values, facts, and personal preferences.

They are now sharing what they have learned with other families in their communities. This project's success is the direct result of the outstanding contributions by these six Illinois farm families and the professional leadership provided by the Extension team. Says Karen Hildebrand, "It's fun and exciting to see what we had planned to do and what we were really able to accomplish!"

To purchase the video, write the authors at the School of Human Resources and Family Studies, 905 South Goodwin Avenue, Urbana, Illinois 61801. Copies are also available to borrow from Illinois county Extension offices.

MaryAnn Paynter, assistant professor of family economics, School of Human Resources and Family Studies, and Duane E. Erickson, professor of agricultural economics



↑ Bureau County's Todd and Gerry Frank share news and dinner.

Value: The Consumer's View on Apparel Retail Stores

Michelle A. Morganosky

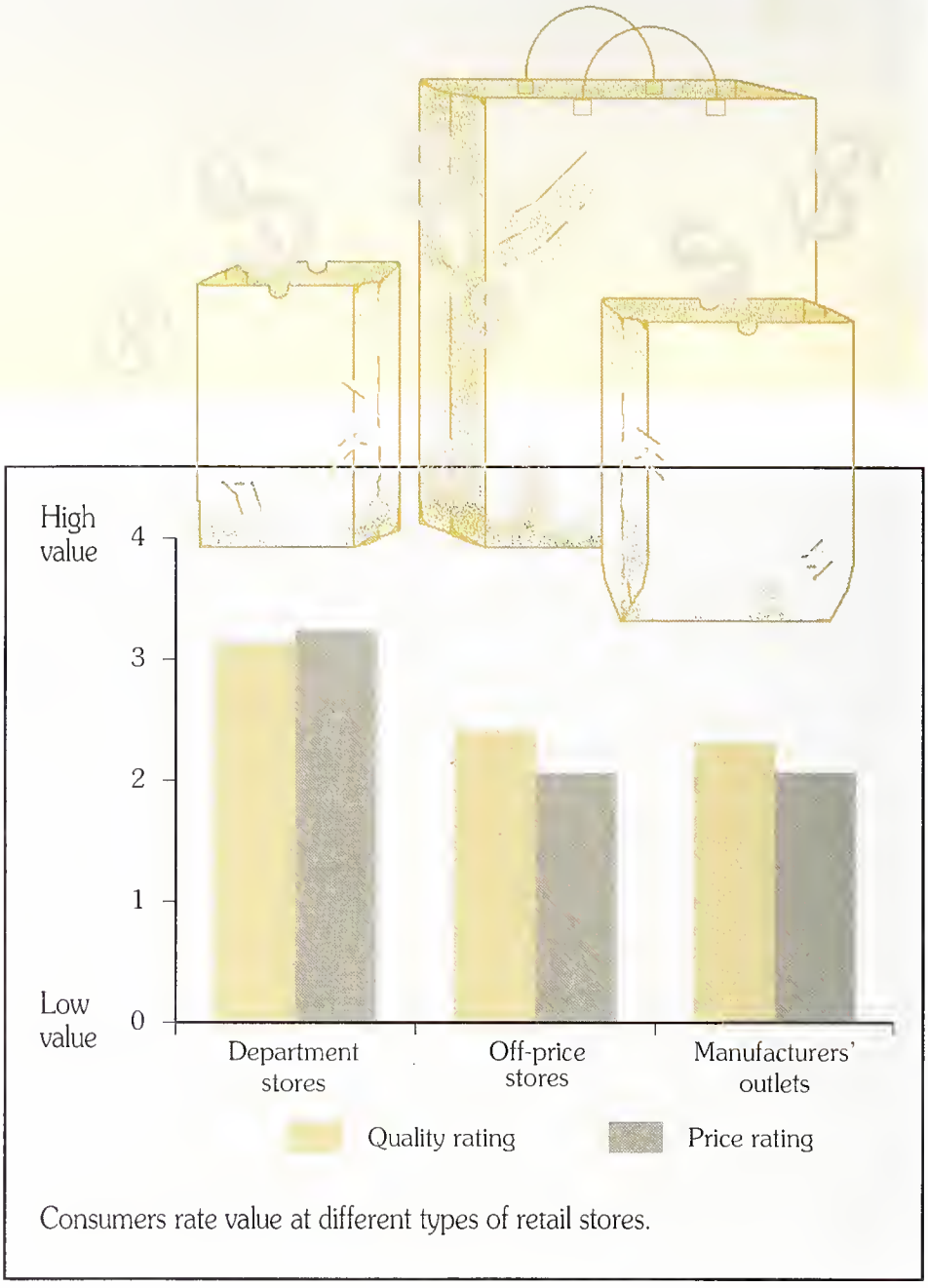
A major factor in whether or not consumers patronize a particular apparel store is how they perceive the "value" that they are offered. Consumers usually try to maximize the trade-off between what they "get" and what they have to "give" in the exchange process. Product quality is very important in this process.

In recent studies at the University of Illinois, interviews were conducted with more than 1,200 consumers throughout the United States. The studies evaluated the relationship between quality and price offered at various types of apparel retail stores.

Consumers' evaluations of this relationship are especially important now due to major shifts in the apparel retail market structure. Traditional forms of retailing, such as department stores, have existed for more than 100 years. But today's consumers are also confronted with newer forms of retailing such as off-price stores and manufacturers' outlets.

During the 1980s, off-price apparel stores and manufacturers' outlets showed significant market-share gains, while department stores lost market share. One explanation is the ability of these newer retail types to deliver value to the consumer through maximization of the price-quality relationship.

Data from a recent study indicate that consumers perceive apparel *quality* at department stores to be highest. Because they perceive *price* at department stores to be even higher, the trade-off between quality and price is less than ideal.

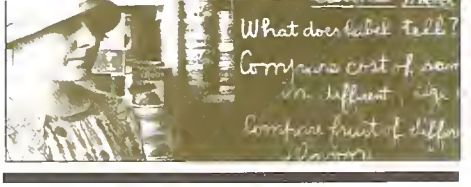


Consumers rate value at different types of retail stores.

At off-price stores and manufacturers' outlets, however, consumers perceive lower prices in relation to quality. Off-price stores and manufacturers' outlets both emphasize name-brand apparel at lower prices than department stores. Because off-price stores purchase merchandise through nontraditional methods, such as buying manufacturers' excess production, they can offer lower prices. Manufacturers' outlets are owned by apparel manufacturers and thus can channel excess merchandise more directly to consumers than other forms of retailing.

Nontraditional retail forms, such as off-price stores and manufacturers' outlets, will most likely continue to experience market-share gains as consumers seek value in the exchange process.

Michelle A. Morganosky, associate professor of apparel marketing, Division of Consumer Sciences, School of Human Resources and Family Studies



Improving Life Management Skills and Technology

Donald A. Holt

Each of us knows individuals and families, within our own income stratum, who manage their personal resources exceptionally well. They create and maintain an unusually good physical, intellectual, and emotional environment for themselves and their families. As a result, they enjoy a high quality of life. But given the same basic resources, others create for themselves and their families a living hell, whose repercussions are felt for generations.

Most people, however, range between these extremes, keenly aware that things could be better but unable to improve them. Although luck may play a role in some of these circumstances, the differences in quality of life generally result from how individuals and their families manage life's basic resources, practices, and technologies.

Skills. The major areas that require good management skills are nutrition, health, housing, clothing, finances, relationships, and personal development. Some of the services associated with these areas include food selection and preparation; maintaining personal health and appearance; home improvement and maintenance; clothing selection, construction, and maintenance; personal and family financial management; scheduling, mutual support, conflict management, and personal counseling; and child care and education within the home.

These activities constitute a vast hidden economy of value added in the home. If these services had to be purchased outside the home, their total cost would equal 0.8 to 1.3 times the gross national product (GNP). Food, clothing, and housing services alone have been estimated at 0.44 times the GNP. Of course, these estimates do not include the value of those intangible services rendered in the home such as mutual psychological support and nurture of families.

Given the universal need for services rendered in the home and their enormous economic and social value, even a minor improvement in managing these activities would have a great positive impact on both the national economy and the quality of life. For example, a modest improvement in family financial management would result in huge increases in investment in both public and private enterprises and a corresponding reduction in the national debt, thus facilitating the resurgence of American competitiveness in the global economy.

National problems. Many current concerns identified as major national problems relate to management of human and economic resources within the home. These problems include homelessness, drugs, alcoholism, teenage pregnancy, AIDS, divorce, crime, poverty, illiteracy, alienation, food safety, smoking, stress, heart ailments, cancer, eating disorders, malnutrition, and numerous others. These problems, many preventable, cause great personal misery. Perhaps even more important, they result in missed opportunities for personal development, contribution, success, fulfillment, and happiness. Thus far, we have not found ways to avoid this incredible waste of human potential.

Benefits of research and education. Almost everyone accepts that research, education, and decision support are vital to improving the management of value-added activities in commerce and industry. Publicly supported research and educational activities improve commercial operations through improved technology and by providing new, better ways to manage operations.

Publicly supported research, education, and decision support also benefit the general public by fostering competition and improving

"Home, what is it? Webster says home is one's dwelling house. Shall we confine ourselves to this definition? Does not home mean more to us than simply a place of habitation? Neither do four walls make a home. No, more than this is required. Home means a generous supply of nature's bounties carefully arranged and tended. It means intelligence at the workstand, it means diligence at the book, it means love at the hearth, it means devotion at the altar."

Miss Marie Cole, Hunnngberg, Indiana, in an address to the 1903 Dubois County, Indiana, Farmer's Institute

↑ An early lesson about value added in the home.

productivity and efficiency of commercial operations. One excellent example is the unprecedented success of U.S. agriculture in providing a high-quality, affordable food supply for Americans.

Because they help people increase their productivity, public research and development often foster competition in the commercial world. Late adopters of improved technology may thus be at a competitive disadvantage. A vigorous, national program of research and development on value-added activities in the home, however, would benefit everyone. The program would focus on deriving maximum benefit from existing resources rather than competing for additional resources.

The Land-Grant Model

The institutional structure of agriculture is our nation's most successful model for publicly supported research and educational activities. A uniquely effective institutional structure resulted from the creation of the land-grant and 1890s institutions (Morrill and Evans-Allen acts), state agricultural experiment stations (Hatch Act), Cooperative Extension services (Smith-Lever Act), and integration of the latter two into the former.

Within these unique institutions were mechanisms to conduct research leading to new technology and improved management, to transfer this technology and information to potential users, and to educate and provide decision support for users. Both formal and continuing educational needs were addressed.

A modest investment of federal funds to create and maintain the land-grant and 1890s institutions triggered and fostered the development of a much larger, more powerful agricultural research and development infrastructure than could be supported by federal funds alone. For example, federal formula funds now provide about 12 percent of the support for the agricultural experiment station system. The rest comes from state and other federal sources, the private sector, and product sales and services from research operations at the experiment stations.

The unique institutional structure of U.S. agriculture propelled our nation's agricultural enterprise into world preeminence and helped it maintain that position for more than a century. The unprecedented success of scientific agriculture provided the economic base for the United States to become the world's dominant industrial force. It seems appropriate to apply this successful model to improving value-added activities in the home.

Problems Facing Home Economics in Land-Grant Institutions

Although state agricultural experiment stations and Cooperative Extension services originally focused on production agriculture, their responsibilities have broadened over time to include many of the home and family concerns mentioned earlier. The home economics programs, however, never received much research support. The modest level of federal support available and production agriculture's tremendous demands for information made it impossible for agricultural administrators to shift much institutional support, including formula funds, to other needs.

Administrators are also reluctant to weaken or destroy existing programs — many of which are extremely productive, useful, and strongly supported by various client groups. Building new programs in different areas, regardless of their potential is difficult. The research programs within our School of Human Resources and Family Studies are the latecomers among programs in the University of Illinois College of Agriculture.

Only twelve of about 165 full-time equivalent scientists conduct home economics research in the College, supported by $1.6 million of the College's $30.4 million total research expenditures. The quality of the home economics programs is excellent, but they are a mere drop in an ocean of problems and opportunities. As long as the Illinois Agricultural Experiment Station is expected to conduct programs of ever-widening scope with static or declining institutional funding, this situation is not likely to improve.

Another problem is that the formulas used to allocate federal resources to state experiment stations and Extension services are inappropriate to support programs that address the needs of an urban population. Factors such as number of farms and farmers are the basis for existing formulas. Formula funds or other institutional funds appropriated to create a research and Extension infrastructure for home and family concerns should be allocated to states in proportion to population.

Over the years, Cooperative Extension services were able to shift some resources to programs focused on family and home concerns. Unfortunately, Extension is not adequately supported to extend these unique educational programs much beyond the rural communities. Also, the experiment station system has not been able to provide Extension people with a sufficient research base upon which to build adequate educational programs on home and family topics.

Applying the Model

The agricultural experiment station system and the Cooperative Extension services networks have the potential to both strengthen essential traditional agricultural programs and create new programs for home and family renewal, without creating new institutional bureaucracy. Land-grant universities provide an excellent setting for basic and applied research and educational programs. The state agricultural experiment stations and Cooperative Extension services have remarkably efficient, highly decentralized systems of resource allocation. In fact, they have the best accounting and management information systems available to any government agencies.

The administrators of state agricultural experiment stations and Cooperative Extension services have statewide administrative responsibilities. Because they can allocate formula funds to qualified persons within any public institution or agency, administrators are in a position to marshal the best public resources available to address public needs and opportunities. Because of their close cooperation with the private sector, the best private resources can be brought to bear on these needs and opportunities as well.

Historically, state agricultural experiment stations and Cooperative Extension services have been involved in research and education programs involving home and family concerns. They have experience in managing these programs, however modest they have been in the past. With a new source of funds, earmarked for research and continuing education programs that address the needs and opportunities within home environments, the existing institutional structure could usher in a new era in quality of life.

Conclusion

A bold, new home economics research and education program, supported initially by public funds, must be launched. It is justifiable on economic grounds alone but has enormous potential social benefits as well. Of course, university administrators are expected to seek support for new programs. Therefore, our requests are often seen as self-serving. We never receive that support, however, unless others outside the institution share our hopes and dreams for these programs. I hope there are others who see the potential I describe here.

To reinforce the ideas presented in this article, the following observations can be made.

- As a nation, we spend tens of billions of dollars annually to improve the technology and management of delivering death and destruction.
- As a nation, we spend hundreds of billions of dollars annually for treatment, care, punishment, and rehabilitation of people afflicted with preventable problems that originate in the home.
- As a nation, we suffer losses of hundreds of billions of dollars annually due to the unachieved potential of human beings whose health, mental capabilities, and attitudes are damaged or otherwise limited by their home environments.

Although these observations are disturbing, they also provide some perspective on the need and opportunity to employ our most constructive, positive, and powerful public institutions — namely, our land-grant institutions — to address the most basic human needs.

Donald A. Holt, Director, Illinois Agricultural Experiment Station

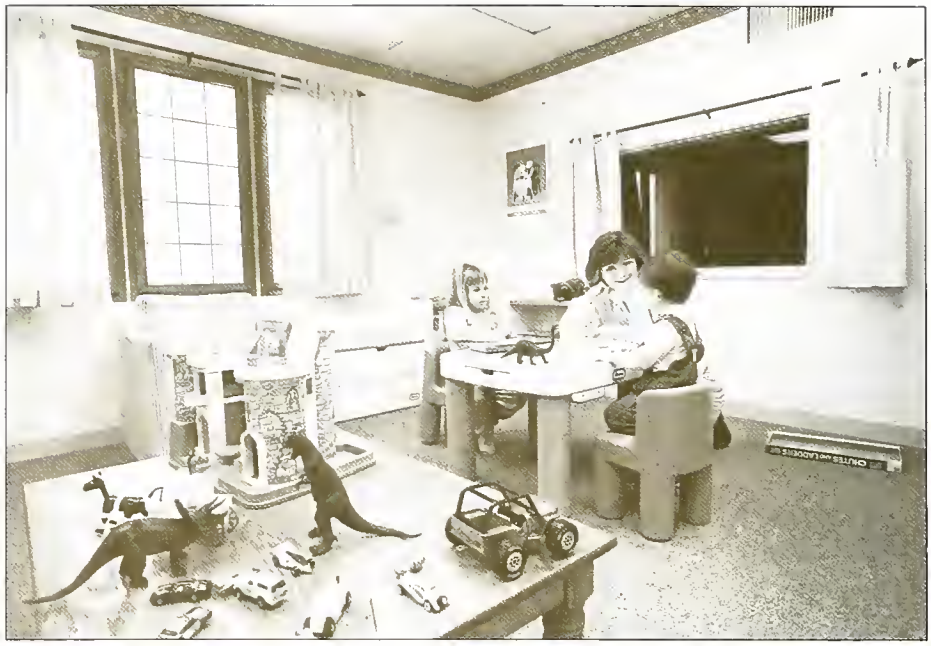
In Progress

Historic Costume Collection Steps Out

The Nettie Lou Samuels Couture and Linen Collections were recently unveiled. The collections were gifts to the Historic Costume Collection of the School of Human Resources and Family Studies. Judith Ikenberry, wife of the University of Illinois president, hosted 250 guests at a high tea honoring Nettie Lou Samuels of Decatur.

A loan of mannequins and personnel from the former Robeson's Department Store of Champaign made it possible to showcase Christian Dior and Pierre Balmain gowns in the grand foyer of the president's house. Intricately designed cocktail dresses and "at homes" from the sixties filled the solarium. Guests delighted in the accompanying text and photographs of the era.

For information about future Historic Costume Collection events, please send your name and address to Betty Alexander, Volunteer Coordinator, 701 West Pennsylvania Avenue, Urbana, IL 61801, or call (217)344-6256.



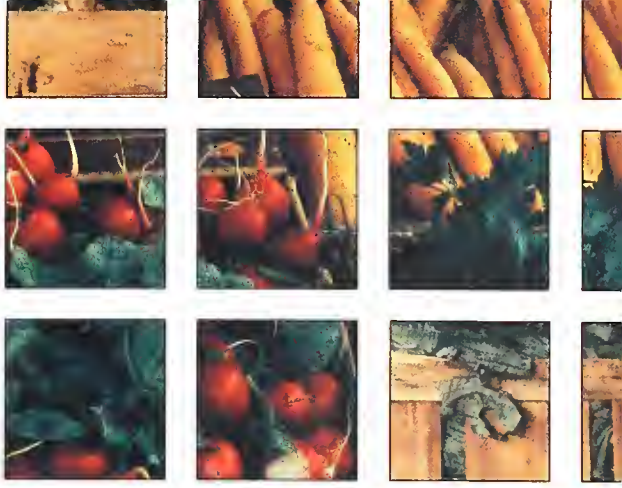
Family Relationships Laboratory Remodeled

The Family Relationships Laboratory in the Child Development Building now has a 1990s look and up-to-date research equipment. Remodeling funds were provided through the University of Illinois Research Board, the Illinois Agricultural Experiment Station, and the Home Economics/School of Human Resources and Family Studies Development Fund.

New furniture, back-lit windows, and two-way mirrors transformed a former kitchen area in the basement into a comfortable, attractive laboratory setting to observe and videotape children and parents. Two new color video cameras and VCR equipment were also purchased for research activities.

Laurie Kramer, assistant professor, Division of Human Development and Family Studies, was instrumental in design and development of the remodeled lab facility.

For Further Reference



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University of Illinois Publications

More than 300 publications, videotapes, and slide sets by specialists at the University of Illinois are available through its Office of Agricultural Communications and Education, 69IR Mumford Hall, 1301 West Gregory Drive, Urbana, IL 61801. Write for your free copy of the *Resources Catalog*, which describes available materials and their prices, or to order publications. (For some publications, the first copy is free. Additional copies must be purchased.) A few titles relevant to this issue are listed below.

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C1182, *Uses and Costs of Consumer Credit*, free ($.50)

C1194, *Consumer Credit: How You Are Protected*, free ($.50)

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C1294, *Shop Smart to Buy More for Less*, $1.75

NCR293, *Buying a Car? Be in the Driver's Seat*, $1.25

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C1304, *1989 65th Annual Summary of Illinois Farm Business Records*, $4

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C1215, *Eating Right During Pregnancy*, $1.50

C1261, *Insuring Your Home*, free ($1)

HEP2, *Illinois Family Account Book*, $1.50

NCR259, *Selling Food Products: A Business from Your Home*, $.75

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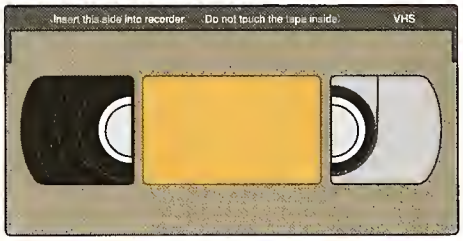

The videos listed are available from the Film Center, University of Illinois, 1325 South Oak Street, Champaign, IL 61820. For information, call toll-free: (800)367-3456.

UIFC X00087, *Changing Directions...The Choice Is Yours* (opportunities for supplemental income)

UIFC X00097, *Empowering Single-Parent Families*

Et Cetera

The following publications are available from the Illinois Farm Electrification Council, University of Illinois, 360-F Agricultural Engineering Sciences Building, 1304 West Pennsylvania Avenue, Urbana, IL 61801.

Lighting for the Home. S. Isabell. 1986. No. 12.

Planning a New Kitchen. J.L. Wysocki. 1987. No. 13.

The following is available from the Small Homes Council–Building Research Council, University of Illinois, 1 East St. Mary's Road, Champaign, IL 61820:

Planning for Remodeling. J.L. Wysocki. 1988. C.8.0.

Illinois Research

Fall/Winter 1990

Creating Diversity in Illinois Agriculture

Illinois Rese

Agricultural Experiment Station
Fall/Winter 1990

Diversity in Agriculture

College of Agriculture, University of Illinois at Urbana-Champaign. Volume 32, Numbers 3/4

The Cover

Wheat field along Route 78 south of Havana in the Illinois River valley.

"At a time unlike any in the past, we must envision the future."

Illinois Research

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Contents

Diversity in Agriculture

Diversity in Illinois Agriculture

Anton G. Endress

The hallmark of Illinois agriculture in this decade will be an accelerated diversification of agronomic, horticultural, and livestock products to accommodate the evolving needs and concerns of both consumers and producers.

Through its traditional research and development roles to enhance the production, processing, marketing, and use of agricultural products, the Illinois Agricultural Experiment Station has kindled significant changes in agriculture statewide. Today we have a greater variety of crop cultivars than ever before. Many of these new cultivars possess improved growth characteristics and yield performance, greater resistance to disease, or more tolerance to the vagaries of weather.

University of Illinois researchers have also helped improve varietal selection and cultural and management practices based on local climate and soil characteristics. And technological advances have spawned new uses for and new ways to process our traditional agricultural products. Thus, new marketing opportunities exist for these products.

Societal concerns will fuel even greater diversity and specialization in the future. The American public has a keen awareness that agriculture is an important part of everyday life and is essential to its long-term prosperity.

Recent concerns include the quality and safety of foods, the use of certain chemicals for weed and pest control, chemical contamination of water supplies and pollution of the air, erosion of valuable soils, climate change from global warming, and the loss of forests and extinction of organisms worldwide. These issues illustrate the public's recognition of the societal benefits to be gained from an agricultural enterprise attuned to a livable environment.

The evolving and expanding needs and desires of consumers dictate the development of different agronomic, horticultural, and livestock products. The public's expanding belief in the necessity of conservation and environmental stewardship

mandates the production of agricultural products in new ways as well. Producers will increasingly be challenged to provide what the consuming public wants.

Consumers are asking for more than just a greater variety of agricultural products. They want those products to be nutritious, of high quality, safe, and affordable. As a result, Illinois agriculture will see rapid change.

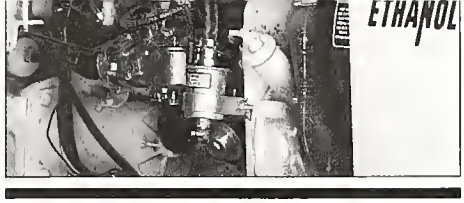
This issue of *Illinois Research* chronicles how diverse Illinois agriculture has become and illustrates the broad dimensions of future product diversification and specialization of both markets and growers.

Illinois agricultural research teams are at the forefront of advances in diversity and specialization. Breeders and biotechnologists continue to improve the traits of our crops and livestock to optimize their adaptation for specialty uses. Our agricultural commodities are being used in many new ways. High-value agricultural products and specialty crops are being studied and developed for targeted domestic and export markets. Production systems using fewer chemicals and less fertilizer are being investigated. Moreover, these advances will probably include the development and adoption of alternative farming practices.

As agriculture continues to diversify, production management will become more important. Producers will need to have a broader mix of knowledge and skills. And management practices will need to be of higher quality and intensity.

In the end, producers and consumers alike will have many more choices. Producers will be concerned with which commodities to produce, for which markets, and using which inputs. And consumers will choose between a greater variety of high-quality, safe, and nutritious agricultural products.

Anton G. Endress, professor and head, Department of Horticulture



Corn and Soybeans: Products, Perspectives, Innovations

David H. Baker

Illinois agriculture is often criticized for its lack of diversity. At first glance, the criticism may seem understandable. After all, 18 million acres of the state's 23 million acres of cropland are devoted to the production of just two crops: corn and soybeans.

But a closer look reveals where the diversity truly lies in regard to Illinois's two biggest crops. The state's endless miles of corn and soybeans eventually are used for a seemingly endless number of products — including meat, milk, and eggs — which find their way into virtually every U.S. household.

Annual corn production in the United States is close to 8 billion bushels; 1.8 billion bushels of soybeans are also produced each year. Illinois ranks first in soybean production and exports. As for corn, it ranks second to Iowa in production but first in the nation in exports.

Illinois corn and soybean production represents 18 percent of the U.S. total. Both corn and soybeans (as meal) are standard ingredients in diets for livestock, poultry, and companion animals.

Among the cereal grains, corn is highest in metabolizable energy. When combined with soybean meal, the high methionine and cystine in corn protein correct the deficiency of these important amino acids in soybeans. Likewise, the rich content of lysine and tryptophan in soybean meal corrects their deficiency in corn. The result is a near-perfect amino acid balance in what is commonly referred to as the corn-soy diet. No other pair of feed ingredients results in a better amino acid balance than corn and soybean meal combined in proper proportions.

Products from Corn

Of the total corn production in the United States, 57 percent is used for livestock feed; 27 percent is exported; and 16 percent is processed for food, seed, and industrial uses. Corn usage for the third category has doubled in the past ten years primarily because of increased demand for high-fructose corn syrup.

Per bushel processed, wet milling of corn produces 32.5 pounds of starch, 1.6 pounds of oil, 2.5 pounds of corn gluten meal, and 11.5 pounds of corn gluten feed (Table 1). Corn gluten meal, used principally in diets for poultry and companion animals, contains 60 percent protein. It is rich in methionine as well as carotenoid-xanthophyll pigments, the latter being important for skin pigmentation of poultry. Corn gluten feed, containing 22 percent protein, is used primarily in swine diets.

Almost 100 percent of the dry matter of corn is recovered in value-added products in the corn wet-milling process. Processing via wet milling is done to produce starch and products made from it. Thus, corn oil, corn gluten meal, and corn gluten feed can be considered byproducts of cornstarch production.

Starch is the starting material for high-fructose corn syrup, glucose, and dextrose. Of the starch that is marketed directly, half goes toward paper production and the other half toward food appli-

Table 1.
Annual Output of Food, Seed, and Industrial Products from Corn in the United States

Product	Estimated quantity	Estimated value
	millions of pounds	*millions of dollars*
High-fructose corn syrup	11,700	2,025
Seed	1,060	1,217
Dry-milled food products	9,020	966
Alcohol	5,530	866
Gluten feed	12,000	650
Glucose syrup	4,610	540
Starch	4,900	510
Gluten meal	2,400	375
Dextrose	1,130	335
Corn oil	1,530	320

Note: Data (1989) furnished by K.D. Brenner, director of public affairs, Corn Refiners Association, Washington, D.C.

cations. Biotechnology contributed to the development of high-fructose corn syrup as an important product for the food and soft-drink industries. The enzymes alpha-amylase and glucoamylase had been available for some time. These enzymes effectively convert starch to dextrose. A biotechnology breakthrough led to a fermentation process for making glucoisomerase, the enzyme that converts dextrose to fructose. High-fructose corn syrup has a "clean" taste. In chilled solutions, the product, containing 90 percent fructose, is about 1.35 times sweeter than conventional sugar (sucrose). The soft-drink industry uses 70 percent of all high-fructose corn syrup produced.

About 60 percent of the alcohol produced from corn (through starch fermentation) comes from the wet-milling industry. The remaining 40 percent comes from dry milling. A bushel of corn will yield 2.5 gallons of ethanol. Most of the ethanol produced from corn is used as a gasoline additive. The dry-milling industry produces corn flours and other products used principally for constructing corn-based foods such as breakfast cereals and corn chips.

New Research with Corn

University of Illinois scientists have been active for many years in efforts to develop corn varieties high in oil or protein. Conventional breeding procedures to produce high-protein corn result in a protein of inferior quality (that is, low in lysine and tryptophan). Therefore, novel procedures have been developed to generate varieties not only high in protein but also high in lysine, tryptophan, and methionine. These varieties have the potential for use in both animal feeds and human foods.

A relatively new product derived from cornstarch is polydextrose, a complex carbohydrate containing only one kilocalorie per gram, about one-fourth the caloric value of starch or dextrose. This product is being marketed to the food industry for use in reduced-calorie candies, puddings, and other products. Several companies are attempting to develop similar products from cornstarch. The Animal Sciences Department at the University developed both the in vitro (chemical) and in vivo (animal) screening procedures that are used to assess caloric content.

Products from Soybeans

During the September 1989 to September 1990 marketing year, 1,783 million bushels of U.S. soybeans were consumed. A total of 62.5 percent was crushed for oil and soybean meal; 32.3 percent was exported; and 5.2 percent was considered "seed, feed, and residual." Of the 66.9 billion pounds of soybeans crushed, 12.4 billion pounds of oil and 52.8 billion pounds of meal resulted. Eleven percent of the oil and 19 percent of the meal were exported. Domestic use of soybean meal consists of 46 percent for poultry, 32 percent for swine, 9 percent for beef cattle, 9 percent for dairy cattle, and 4 percent for other species. Data in Table 2 provide a distribution of domestically used soybean oil.

The oil extracted from soybeans represents 36 percent of the total value of the crop. Upon solvent extraction, one bushel of soybeans yields 11.1 pounds of oil. Close to 98 percent of the oil is manufactured into food products.

A small percentage of crushed soybeans is converted into edible soybean flours and concentrates for humans. An estimated 750 million pounds of these materials were produced in 1985. And markets for these products are expanding, particularly for alcohol-extracted material. Alcohol extraction removes most of the oligosaccharides (complex carbohydrates) from soybeans, thereby minimizing flatulence problems associated with oligosaccharide consumption. The University's Department of Food Science has been a leader in research designed to develop palatable and nutritious food products from not only soybeans but also corn.

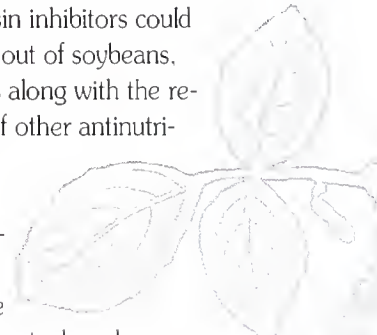
Table 2.
Soybean Oil Usage in the United States

Product	Estimated quantity
	millions of pounds
Cooking and salad oils	5,068
Shortening	3,854
Margarine	1,675
Other foodstuffs	139
Resins and plastics	97
Soaps and miscellaneous	82
Paint and varnish	55
Fatty acids	30
Total	11,000

Note: Data are estimates for the 1989–1990 marketing year based on information presented in *Oil Crops Situation and Outlook* (October 1989), USDA, ERS; and *Soya Bluebook*, 1986.

New Research with Soybeans

Agronomists at the University have developed a soybean variety devoid of the Kunitz trypsin inhibitor, a protease enzyme inhibitor that lowers protein digestion in monogastric animals such as pigs, chickens, and humans. Work is continuing toward the development of varieties lacking other antinutritional factors as well. If all trypsin and chymotrypsin inhibitors could be bred out of soybeans, perhaps along with the removal of other antinutritional factors, raw soybeans could be fed to livestock and companion animals without heat processing. Even with other antinutritional factors still present, having a



Ethanol can be used as an alternative to petroleum-based fuel.

Kunitz-free soybean means that less heat processing will be required to deactivate the non-Kunitz protease inhibitors. This energy-saving phenomenon is extremely important to the soy processing industry.

Research with pigs and chickens at the University has led to an *in vitro* test in which soybean protein is dissolved in 0.2 percent potassium hydroxide (KOH) to determine whether soybean meal has been overheated. The KOH solubility test has considerable potential for use in the food and feed industries as a quick and simple *in vitro* test for predicting *in vivo* protein quality of soybean meals and flours.

Researchers are evaluating soybean oil's potential as a replacement for diesel fuel and as a raw material for printing ink. As a food-grade product, soybean oil contains about 12 percent saturated fat. Its unsaturated fat consists of 10 percent triglyceride-containing omega-3 fatty acids. These fatty acids are among the important components of marine and canola oils, thought to prevent atherosclerosis in humans. By comparison, only 1 percent of the fatty acids in corn oil are omega-3. Nonetheless, both corn oil and soybean oil are rich in polyunsaturated fatty acids, which are believed to help prevent high blood cholesterol in humans.

Research at the University has shown that feeding soybean oil to pigs increases the omega-3 fatty acid content fourfold in both loin muscle and subcutaneous fat. Although this increase is dramatic, it is important to note that even in pigs fed soybean oil, the omega-3 fatty acid content represents only about 0.5 percent of the total fatty acids in pork loin and about 1.2 percent of the total in subcutaneous fat.

Recent research at Iowa State University has resulted in a soybean variety with only 6.2 percent saturated fat. More importantly, the concentration of palmitic acid, a saturated fatty acid, is reduced from 10 percent in standard soy oil to only 3.5 percent, about the same as in canola oil. Palmitic acid has been shown to elevate serum cholesterol. Because canola oil is low in saturated fat and high in omega-3 fatty acids, it has received endorsements from health associations such as the American College of Nutrition. As a result, canola oil has cut into the market for U.S. soybean oil. If the genes that lower palmitic acid concentration can be bred into existing high-yielding varieties, significant new markets could develop for low–palmitic-acid soybean oil.

Looking Toward the Future

Eventually, the reduced supply and increased price of petroleum will open new opportunities for manufacturing fuels and industrial chemicals from corn using environmentally sound methods. Petrochemicals now are used to produce 9.6 billion pounds of ethylene and 6.6 billion pounds of propylene each year for plastics manufacturing. Researchers, with the help of biotechnology, have developed methods for producing a multitude of industrial chemicals from corn. Although current methods involve fermentation of cornstarch to produce ethylene and propylene, University scientists are evaluating fiber-digesting bacterial processes to convert fibrous waste materials such as corn stalks and corn cobs into useful organic chemicals. They are also searching for cost-effective ways to make calcium magnesium acetate (CMA) from corn.

CMA has the same ice-melting properties as calcium chloride, which is used to keep roads and bridges from becoming iced over. Unlike calcium chloride, however, CMA is biodegradable and does not cause motor vehicles to rust.

Corn and soybeans, in contrast to petroleum, are renewable resources. Both products have a brilliant and still unrealized future. Farmers and food processors in Illinois are ideally situated to take full advantage of what some have called "the best location in the world to produce *both* corn and soybeans."

David H. Baker, University scholar and professor of nutrition, Department of Animal Sciences and Division of Nutritional Sciences

The Economics of Diversity

Steven T. Sonka and Sarahelen Thompson

The overall food and agribusiness industry in Illinois constitutes a large and diverse component of the state's economy. Food processing alone generates more than $19 billion annually. Indeed, all sectors of the industry, including farm equipment manufacturing, farm input suppliers, grain elevators and merchandisers, and the associated agricultural services, contribute to the economic well-being of the state.

But in spite of the variety found in its overall food and agribusiness sector, Illinois has seen a decline in the diversity of its production agriculture. As the dynamics of agricultural economics have changed over the past thirty years, so have the production practices of farmers.

Illinois Farms: Then and Now

Agricultural production in Illinois is considerably different today than it was just a few decades ago. One example of the changes that have occurred can be seen in the mix of crops produced. Figure 1 compares the proportion of acreage devoted to five major crops — corn, oats, wheat, soybeans, and hay — in Illinois for the periods of 1957–59 and 1985–87.

Although the total acreage of crops in the 1950s as compared to the 1980s is fairly consistent, the mix of crops differs dramatically. The major change is the drastic increase in acreage devoted to soybeans. Over four million more acres were devoted to the soybean crop in the 1980s than were planted to soybeans just thirty years previously. Clearly the "soybean miracle," in terms of both production technology improvements and growth in demand, has had a major impact in Illinois.

Those four million additional acres of soybeans had to come from other uses. Part of the acreage came from oats and hay, whose total acreage has dropped sharply since the 1950s (Figure 1). Another interesting feature shown in Figure 1 is the different levels of diversification in the two periods. In the 1950s, crop acreage was more evenly distributed between several crops. In the 1980s, acreage was dominated by corn and soybeans.

In addition to looking at crops and state acreages, it is useful to consider diversity in terms of agricultural production on individual farms. (Keep in mind that not only crops but also livestock are important components of Illinois agriculture.) Three snapshots of livestock agriculture in Illinois are shown in Figure 2. As can be seen, the number of farms reporting production of the three main types of Illinois livestock — beef cattle, dairy cows, and swine — decreased over the past thirty years.

Total livestock numbers have also fallen, but not to the extent that the number of farms producing livestock has declined. The number of beef cows declined by 57 percent between 1959 and 1987. Milk cow numbers fell by 66 percent during the same period, and hogs and pigs fell by 32 percent. Increasing specialization of production on individual farms explains why the number of farms has declined more sharply than has the number of livestock produced.

Not surprisingly, the massive decline in the number of farms producing livestock during the 1960s and 1970s coincided with a major expansion in soybean acreage and a decline of oat and hay acreage during the same period. The trend toward specialization continued throughout the 1980s.

But why did the trends away from diversity and toward specialization occur in the first place? And will they continue?

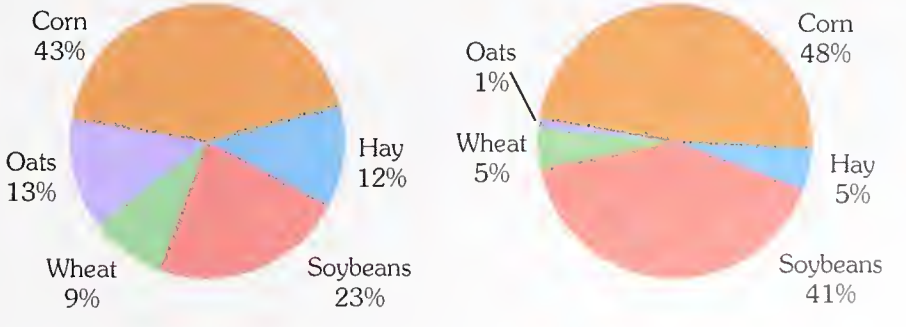


Figure 1. Major crops in Illinois: the 1950s versus the 1980s.

Economic Forces Affecting Diversification

For many years, agricultural economists have been analyzing the forces that affect diversification. Their analyses have identified numerous factors influencing diversification. Some factors encourage it and others do not.

Three of the most influential economic forces in Illinois are comparative advantage, scale economies, and risk management.

Comparative advantage. This concept holds that people in two regions will be better off if, rather than both undertaking all activities, each region specializes in the activity it does best and then trades with the other region. The activities that each region should engage in are those for which it has the greatest "comparative advantage."

Let's consider an example. Beef cows can be raised in both Illinois and New Mexico. In Illinois a cow and calf might require an acre of grazing land. In New Mexico more than ten acres would be needed for that same cow and calf. Yet beef cattle production is relatively much more important in New Mexico than in Illinois.

The reason for this seeming paradox is that Illinois enjoys a comparative advantage in the production of other commodities, such as corn and soybeans. Therefore it is more economical for each of the states to specialize in production and then trade with the other state for agricultural commodities and products that it does not produce.

The idea of comparative advantage is just as relevant for individual farms as it is for regions and states. For example, one producer may have resources and skills best suited to producing soybeans and corn. Another producer may have interests and abilities better suited for swine production. Therefore, if these producers maximize comparative advantage, they will tend to become more specialized.

Technology plays a key role in determining comparative advantage. Clearly the use of agricultural chemicals to control pests reduced the need for rotations, fueling the types of acreage changes shown in Figure 1. And advances in confinement livestock production facilitated the changes shown in Figure 2.

Scale economies. This term refers to the extent to which production costs decline as output increases. These cost savings, or economies, are a major cause of specialization. Scale economies often exist because of large fixed costs for machinery and equipment that decline on a per-unit basis as output increases. Where substantial scale economies exist, firms will tend to specialize to produce enough output to take advantage of those economies.

As production agriculture has become more scientific, managerial attention and capability have been added to the list of factors associated with scale economies. It takes time to remain current with all the changes and advances associated with today's production agriculture. The producer trying to keep up to date on four or five commodities has a much more difficult task than does the producer concentrating on just one or two.

Risk management. A negative feature of specialization is that the producer is more vulnerable to the sharp swings of price and production that characterize farming. The completely specialized producer has put all the firm's eggs in one basket. If incomes are low in that basket, no other enterprise exists to offset the decline.

However, today's producer has a number of means to counteract this financial risk that may not be apparent by just considering the number of crops and livestock enterprises that exist. Examples include government farm programs, off-farm income, and financial and marketing instruments.

Earlier we looked at acreage in five major crops in Illinois. One major "crop" not considered was acreage idled because of government farm income support programs. These programs used one to three million acres in the state between 1987 and 1989. By providing income stability, income support programs are felt by many to have contributed to the specialization of crop and livestock production.

Off-farm income is another means of diversification. In 1987, 22 percent of the nearly 63,000 commercial farms in Illinois (those with sales in excess of $10,000) reported more than 200 days of off-farm employment. Clearly the presence of this additional flow of revenues

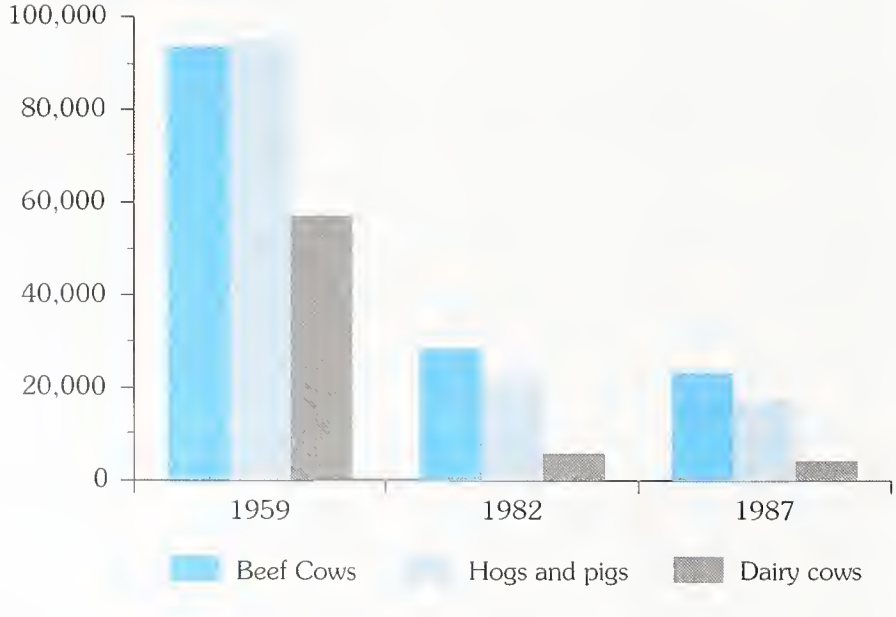


Figure 2. Farms with livestock in Illinois: 1959, 1982, and 1987.

Thirty years ago, many farmers raised livestock in addition to growing field crops (above). Since then, a trend toward specialization has changed the look of Illinois agriculture (below).

could affect the producer's need to diversify to stabilize agricultural receipts. Additional nonproduction instruments for stabilizing income flows include hail and all-risk insurance, forward contracting, hedging with futures contracts, and using options on futures contracts.

Is Diversity in Our Future?

During the late 1950s it is not likely that anyone would have correctly foretold all the changes we have witnessed in the last thirty years of Illinois agriculture. Our crystal ball is not necessarily any brighter today than it was then. Therefore, an attempt to predict specific changes to occur in the future would be feeble at best.

There are, however, three major forces that are likely to affect the state's agricultural diversification (or lack thereof) during the 1990s. They are environmental concerns, high-value agricultural products, and government intervention.

Environmental concerns. The technologies that facilitated the growth of row-crop agriculture in Illinois are now being blamed for creating chemical residues in ground water and soil erosion.

Societal responses to these environmental concerns may affect the comparative advantage of alternative commodities and production systems. These responses most likely will include the development and adoption of alternative farming practices to increase diversity on individual farms and protect the state's natural resources. For further discussion of this topic, see the fall/winter 1989 issue of *Illinois Research*, which focused on sustainable agriculture.

High-value agricultural products. Biotechnology, changing consumer preferences for food, and rising consumer incomes have increased the potential for economic production of high-value products. Examples include specialty crops such as baby vegetables and shiitake mushrooms, as well as alternative crops such as canola and specific soybean varieties for targeted export markets.

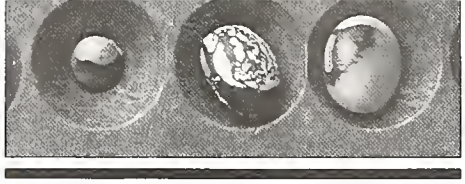
Although an increase in high-value agricultural products could enhance the diversity of Illinois agriculture, it could also present a number of interesting problems. Marketing challenges may be difficult to overcome in many of these situations. For further discussion, see the spring/summer 1989 issue of *Illinois Research* ("The Risky Business of Thin Markets," by Sarahelen Thompson).

Government intervention. Probably the single most contentious international trade issue over the last five years has been the agricultural support policies of the major world traders. The success of the current General Agreement on Tariffs and Trade (GATT) negotiations is widely believed to hinge on an agreement on agricultural protection being reached among the United States, the European Economic Community, Japan, and the other major agricultural exporting nations.

If agreements to reduce trade-distorting subsidies are reached, major changes in government support policies will occur. Coupled with concerns over the nation's budget deficit, these changes could reduce direct government subsidies to agriculture.

Assuming that government support payments have contributed to agricultural specialization, it is logical to expect reductions of those payments to lead to reduced pressures for specialization.

Steven T. Sonka, professor of agricultural economics, and Sarahelen Thompson, associate professor of agricultural economics



Differentiation in Grain Commodity Markets

Marvin R. Paulsen

As we explore diversity in the agricultural commodity markets of Illinois, it becomes obvious that just as all grain varieties are not alike in yield potential, they are also not alike in end-use value. Despite this fact, however, U.S. grading standards traditionally have tended to promote the idea that "all grain is alike."

Grade distinctions traditionally have been determined by factors relating to the condition of the grain at the time of its sale. Such factors may include percentages of broken material; mold-, insect-, or heat-damaged kernels; and test weight. But intrinsic factors such as chemical composition and kernel hardness also contribute to the grain's value. A system for distinguishing grades based on these intrinsic characteristics could provide for greater differentiation in grain markets.

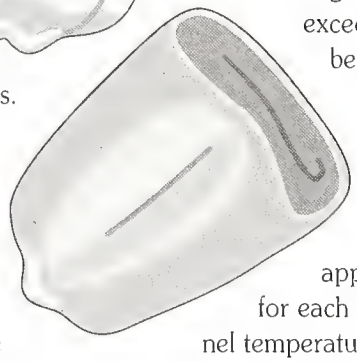
Corn Quality Characteristics

Other than seed production, there are four primary uses for corn. More than 75 percent of U.S. corn goes to feeding livestock and poultry both here and abroad. Another 13 percent to 15 percent is used for wet milling. Dry milling and alkaline processing combined use about 2 percent to 3 percent. Assuming moisture content and mold-damage levels are sufficiently low, corn produced for each of these purposes has specific intrinsic factors that help define its value as a commodity.

For livestock and poultry feeding, chemical constituent contents are important. Feed rations are often tailored to the protein content available in a corn lot, resulting in cost savings. Opaque-2 corn is desirable for feeding because of its high content of lysine and tryptophan, two important amino acids. Because of its reduced zein protein, however, opaque-2 corn has predominantly soft endosperm, making it easy to break.

Swine benefit from diets of high-lysine and high-oil corn. High-lysine corn improves feed gain for nursery pigs. High-oil corn has been used in nursery and lactation swine rations to provide additional energy and reduced dust.

Improvements in technology, such as near-infrared reflectance (NIR) and near-infrared transmittance (NIT) units, have made it faster and easier to analyze corn samples. As this new technology becomes more widely available to provide rapid protein, oil, moisture, starch, and fiber analysis, markets will become more specialized. This will lead to more requests for specialty corn for feeding operations.



Timely harvest in many cases necessitates high-temperature drying of corn, resulting in a quality level that is lower than expected. But because feeding requires so much (more than three-quarters) of our annual corn production and high-temperature–dried grain is suitable for livestock, there is always a market for such grain.

For wet milling, corn is steeped in a sulfur-dioxide solution for twenty to thirty-eight hours at 122° to 131°F. This process separates out the germs and fiber, leaving a starch-gluten slurry. The purpose is to obtain food starch, or to produce fructose or ethyl alcohol.

The variety of corn affects the type of starch obtained. Waxy corn (99 percent amylopectin) produces a high-viscosity starch used for food stabilizers and thickeners. High-amylose corn (50 percent amylopectin, 50 percent amylose) produces a starch that resists swelling, withstands high-temperature cooking, and forms strong gels that are used as stabilizers in confectionery products. Normal dent corn (33 percent amylose, 67 percent amylopectin) is the preferred type for producing food starch and sweeteners.

Drying corn at lower temperatures is also important for obtaining good starch recovery percentages in wet milling. If kernel temperatures exceed 140°F, the protein may be denatured, making the separation of starch from protein gluten more difficult, leading to reduced starch yield in the wet milling operation. As an approximate rule of thumb, for each 10°F increment that kernel temperature increases over 140°F,

starch yield decreases by one percentage point.

Excellent corn for wet milling can be obtained using natural-air or low-temperature drying methods. For increased drying speed, combination drying (where the moisture below 20 percent is removed with low heat) can be used. For higher drying capacity, concurrent flow dryers with tempering can be used if kernel temperatures do not exceed 140°F.

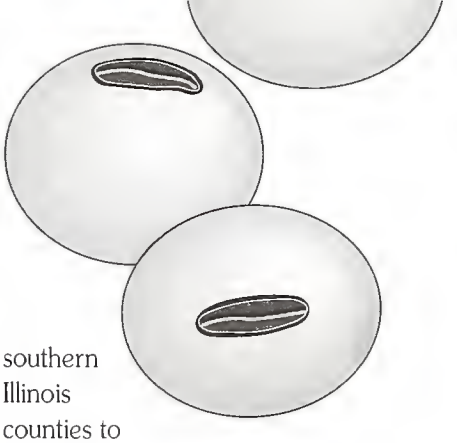
For dry milling, kernel hardness is most important. Hardness is defined as the amount of vitreous endosperm relative to the amount of floury endosperm. The harder the corn, the higher the ratio of vitreous to floury endosperm. The purpose of dry milling is to remove the germ and to obtain large pieces of vitreous endosperm, which make up the large flaking grits. These large grits are used to make corn flakes. Thus, hard-endosperm corn results in higher yields of large corn flakes than soft-endosperm corn. For corn used in snack foods and alkaline processing, hard endosperm is again desirable.

Corn hardness is determined primarily by variety. Under dry growing conditions, however, endosperm tends to become harder than it would were ample moisture available. Generally, as corn hardness increases, kernel density increases, kernels exhibit greater resistance to grinding, and ground particle sizes are larger than for soft corn.

Soybean Quality Characteristics

Soybeans are primarily used for processing into oil and meal. The percentages of oil and protein in soybeans used for domestic crushing are usually not measured. In September 1989, however, the Federal Grain Inspection Service (FGIS) started providing protein and oil measurements as official criteria if requested.

Soybeans vary in protein and oil both by variety and growing location. In 1989 the Identity Preserved Grain Laboratory in Urbana, Illinois, found protein to vary significantly — from 35.8 percent in



southern Illinois counties to 33.5 percent (at 13 percent moisture) in east-central counties. Percentages of oil ranged from 19.9 percent (at 13 percent moisture) in east-central counties to a low of 18.6 percent in southern counties.

For soybeans purchased for processing, an estimated process value (EPV) was calculated. EPV provides a prediction of the value of a bushel of soybeans based on its protein and oil composition, normal processing conversions, and the current price of crude soybean oil and 44-percent soybean meal. In this example, EPV ranged from $6.59 per bushel in southern Illinois to $6.41 in eastern Illinois. These values were based on 19.3 cents per pound for crude soybean oil and $183.10 per ton for soybean meal. The soybean variety greatly affects EPV.

A soybean processor would prefer to know EPV. But a producer would prefer to know the estimated process value per acre (EPVA), which takes into account the soybean yield per acre. There is no incentive for a farmer to plant a soybean variety with an excellent EPV value unless it also has a high EPVA value.

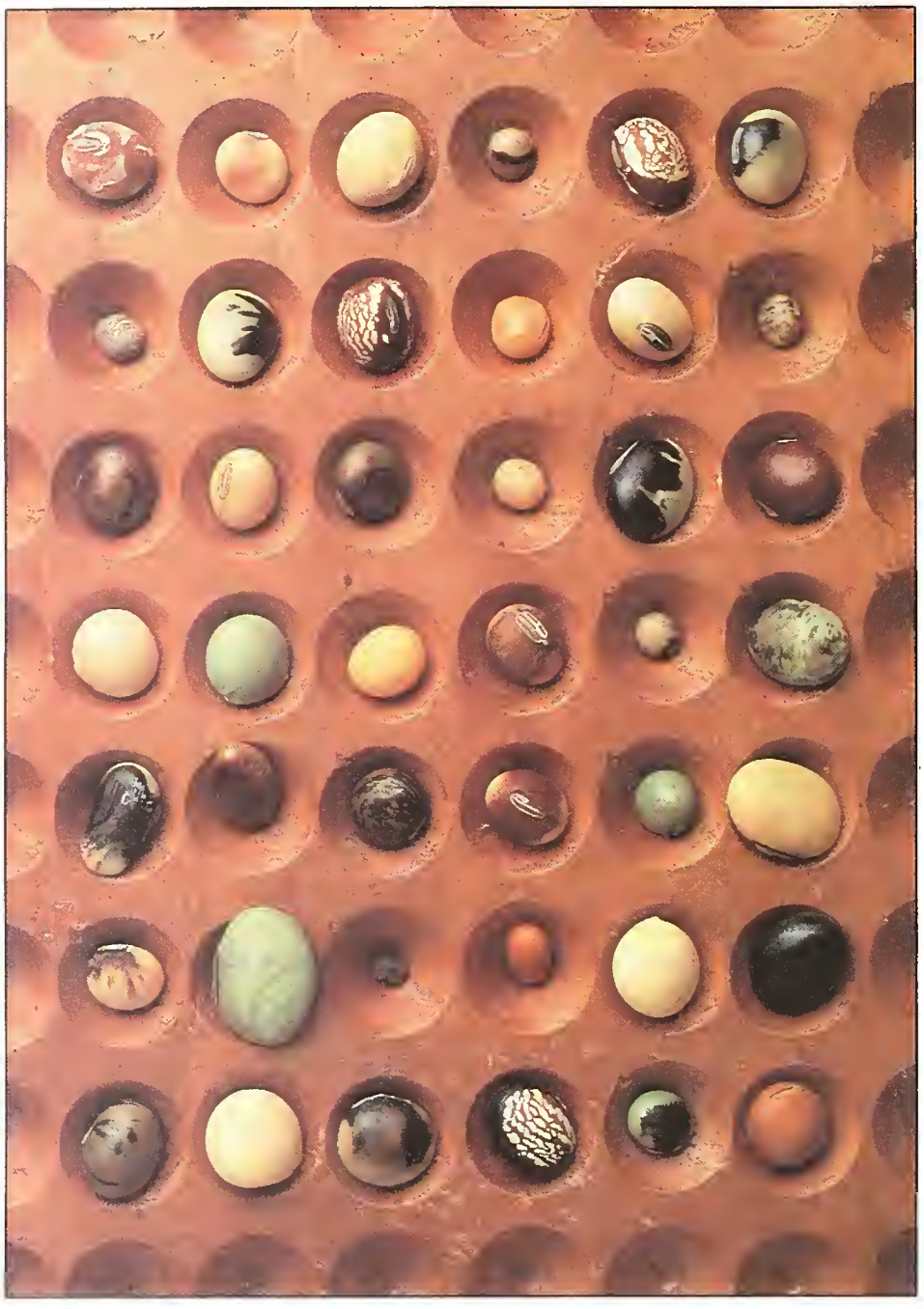
In a comparison study of Group III soybeans in thirty-inch rows grown at Urbana in 1989, the Identity Preserved Grain Laboratory found the EPVA to vary from a high of $489 per acre to a low of $289 per acre. The variation was due primarily to variety selection. With sufficient market incentives, it is possible to select varieties with relatively high EPVA *and* EPV values.

The American Soybean Association (ASA) has recommended that new soybean varieties have protein and oil percentages that sum to 62 when expressed at 0 percent moisture. For example, the east-central Illinois averages of protein at 33.5 percent at 13 percent moisture would be 38.51 percent at 0 percent moisture. The averages of protein at 19.9 percent at 13 percent moisture would be 22.87 percent at 0 percent moisture. These numbers sum to 61.38. This average value is below the recommended 62, yet many of the *individual* varieties had sums greater than 62.

The relative value of protein versus oil continually shifts with meal and oil market prices. The position ASA has taken is that selection should be made for high protein, citing that a 1 percent increase in protein reduces oil by 0.25 percent, whereas a 1 percent increase in oil results in an average decrease of 1.3 percent in protein. Further, the higher the protein the lower the fiber, and a more favorable amino acid balance results.

One of the major changes creating differentiation in soybean markets has been the introduction of the new Kunitz soybean, recently developed at the University of Illinois. The Kunitz variety, which can be fed to livestock without processing, could provide an alternative protein source in regions where soybean meal is not readily available. The Kunitz soybean also could lead to cost savings in processing by reducing the need for heat-roasting. (See related article on page 4 for more on the Kunitz soybean.)

Another important market for soybeans is the tofu industry. For this use, important characteristics are high protein and a light-colored hilum. A black hilum causes the tofu product to lose its traditional creamy white color. Yield of tofu increases as the percentage of protein recovered during processing increases. Desirable tofu soybeans should have a moisture content of 13 percent or less; a protein content of 36 percent or more at 13 percent moisture; a hilum color of brown, buff, clear, or imperfect black; medium-sized seed (2,300 to 2,500 seeds per pound) and U.S. No. 1 or better for foreign material, splits, and



Soybeans come in many shapes and sizes.

damage factors. These criteria were established by the Identity Preserved Grain Laboratory.

Wheat Quality Characteristics

Traditionally wheat has been ahead of corn and soybeans in the tests performed relative to end use. Most wheat is milled to produce flour for human consumption. There are primarily five classes of wheat grown in the United States. Hard red spring wheat and hard red winter wheat are preferable for use in yeast breads and hard rolls. Durum wheat is used for macaroni and spaghetti. Soft red winter wheat, grown in the eastern half of the nation, is used for making cakes, pastries, flatbreads, and crackers. Soft white wheat — used for noodles, cakes, pastries, flatbreads, and crackers — is grown mainly in the Northwest, New York, and Michigan.

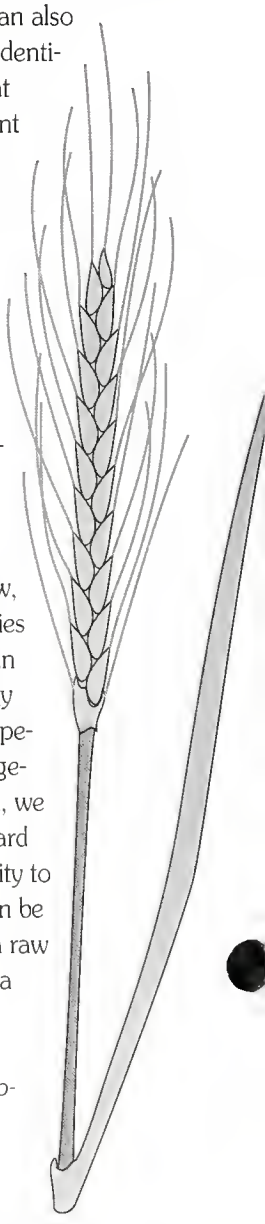
In the past, only the class of wheat needed to be known to select for best end use. Wheat classes were determined by visual inspection. But over the years, plant breeders have crossed soft red wheat with hard red wheat to improve disease resistance and yields. The resulting crosses have the visual characteristics of soft wheat yet the functional characteristics of hard red wheat.

The mixed characteristics of new wheat varieties can lead to misidentification of wheat types and eventual problems at the processing plant. For instance, a wheat mill designed for soft wheat cannot produce the expected flour if hard wheat is mixed in with the soft wheat.

Actual wheat varieties can be identified by electrophoresis to analyze gliadin, a major protein contained in the wheat gluten. High-performance liquid chromatography (HPLC) can also provide good varietal identification. It is likely that tests for protein content and quality and kernel hardness will be needed to correctly classify wheat for class and end use.

The grain commodity markets in Illinois are experiencing more and more differentiation. These changes are fueled by consumer needs that continue to require new, specialized grain varieties and by improvements in the research technology used to identify these specialized grains on a large-scale basis. As a result, we are seeing a trend toward greater market sensitivity to intrinsic factors that can be used to better predict a raw commodity's value for a particular end use.

Marvin R. Paulsen, professor of agricultural engineering



How Sweet It Is

J.W. Courter and Floyd S. Ingersoll

Ninety-eight-year-old Martin Miller of Indianapolis has been growing Xtra-Sweet hybrids for 25 years. He calls them "the very best sweet corn available."

Sweet corn keeps getting sweeter. Thanks to nearly thirty years of plant breeding and hybrid development, today's consumer can purchase tasty hybrids up to four times as sweet as "standard" sweet corn.

Researchers have identified a number of different genes that increase sugar levels above that found in standard sweet corn. New varieties possessing these genes may contain as much as 12 percent sugar by fresh weight. They may also have unique eating, freezing, or canning qualities.

For many years, the only choice available was standard sweet corn, a variety containing about 6 percent sugar by fresh weight. Plant breeders called the variety "sugary" by virtue of its *su* gene, which causes sugars, rather than starch, to be stored in the kernels.

Considering Illinois's distinction as a top corn producer (third among states in production of corn for processing and tenth in production of fresh-market corn), it is no surprise that the University of Illinois has led the effort to improve the quality and variety of sweet corn. Indeed, the two dominant types of high-sugar sweet corn on the market today, the *shrunken-2 (sh_2)* and *sugary enhancer (se)*, both were developed from basic research at the University.

In the early 1950s, John R. Laughnan of the University's Department of Botany discovered the high-sugar *shrunken-2* gene. At that time, his discovery was considered a novelty. The first commercial hybrid, Illini Super Sweet, was introduced in 1960 by Illinois Seed Producers Association, Inc. (now Illinois Foundation Seeds, Inc.). This was followed by an improved hybrid named Illini Xtra-Sweet and by Early Xtra-Sweet, an All-America Selections winner in 1971. These hybrids, which tend to be less creamy and more crispy in texture than standard sugary sweet corn, have become popular worldwide. For example, commercial *shrunken-2* hybrids have captured more than 75 percent of the market in Japan and 95 percent of the market in Taiwan.

The *sugary-enhancer* gene was discovered in 1967 by A.M. Rhodes in the Department of Horticulture. Hybrids containing this gene vary in kind and amount of sugar as well as eating quality. Some customers prefer the creamy texture and flavor inherent to these hybrids.

Today, a large number of *shrunken-2* and *sugary enhancer* hybrids are suitable for planting in Illinois. These new hybrids are up to four times sweeter than standard sweet corn forty-eight hours after harvest. Researchers are also working to improve germination, plant vigor, and disease resistance of high-sugar corn.

The texture, flavor, and color of new sweet corn cultivars vary with the genetic type. Today's consumer can find subtle texture and flavor differences in yellow, white, and bicolor (mixed yellow and white kernels) sweet corn.

Growers must "know their corn genes" before planting fields or gardens. Cross-pollination of unlike genotypes may result in undesirable, starchy kernels.

Americans simply love corn. Each year we gobble down more than eleven billion ears of fresh or home-processed sweet corn. And consumption should continue to grow as hybrids are developed with a range in sweetness, distinctive flavors and textures, and improved shipping and handling characteristics.

J.W. Courter, professor of horticulture and Extension specialist, Dixon Springs Agricultural Center, Simpson; and Floyd S. Ingersoll, executive vice president, Illinois Foundation Seeds, Champaign

A World of Opportunities Is Cropping Up

Emerson Nafziger

Although corn and soybeans would be hard to replace for most feed and export markets, many alternative crops have a strong potential to succeed in other markets.

Corn and soybeans provide a good balance of protein and calories (carbohydrates plus oil) for the animal-feed and export markets. Given the tremendous genetic improvement of these crops and the comparative advantage they enjoy in Illinois, it would be hard to find a new crop that would provide either protein or calories more efficiently (that is, more cheaply). Instead, it may be more appropriate to look for a crop that will be used for new products, for which prices may be higher.

Before deciding to grow a new crop, producers need to consider not only its agronomic adaptability but also its marketing potential. The latter is largely determined by the crop's eventual uses. The success of a new crop depends on good yields of a marketable product.

Table 1 lists a number of crops that are grown somewhere in the world and for which markets, or market potential, do exist. Each crop's most common uses are given, along with the author's ratings for the crop's agronomic and marketing potential in Illinois. The agronomic rating takes into account not only climatic adaptation and yield potential but also expected yield stability. Likewise, the marketing rating incorporates crop use, production in other countries, and the value of the end products. Finally, the agronomic and marketing ratings are combined to give an index of potential for the crop to succeed in Illinois.

There are, of course, many other crops grown in the world besides those

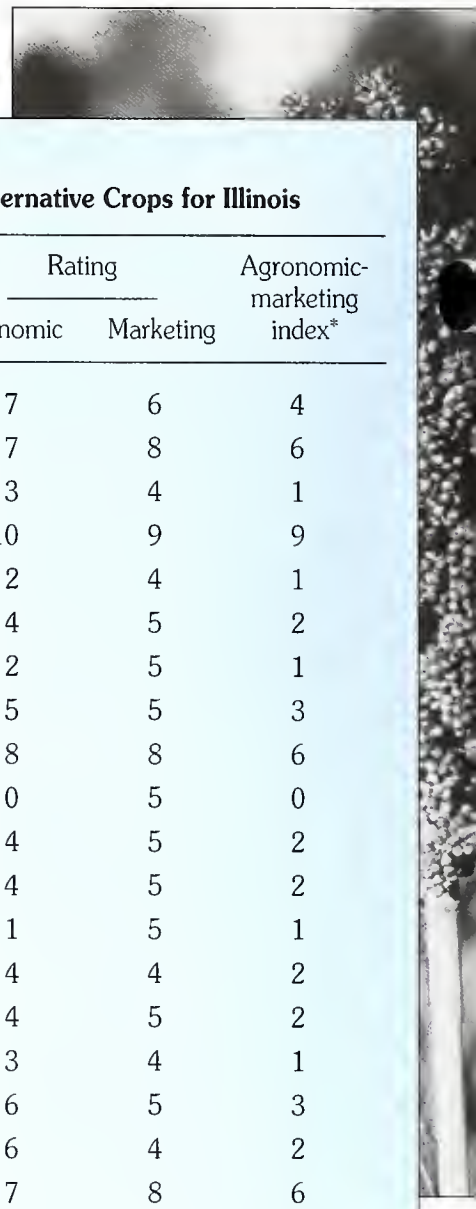


Table 1.
Agronomic and Marketing Potential of Alternative Crops for Illinois

Crop	Use	Rating		Agronomic-marketing index*
		Agronomic	Marketing	
Amaranth	Food	7	6	4
Canola	Oil, meal	7	8	6
Chickpea	Food	3	4	1
Corn	Feed	10	9	9
Cotton	Fiber	2	4	1
Crambe	Industrial oil	4	5	2
Cuphea	Manufacturing	2	5	1
Dry beans	Food	5	5	3
Grain sorghum	Feed	8	8	6
Jojoba	Wax	0	5	0
Kenaf	Woody fiber	4	5	2
Lentil	Food	4	5	2
Lesquerella	Industrial oil	1	5	1
Lupins	Feed	4	4	2
Meadowfoam	Industrial oil	4	5	2
Milkweed	Down, organics	3	4	1
Millet	Feed	6	5	3
Mungbean	Food	6	4	2
Oats	Food, feed	7	8	6
Palm	Oil	0	7	0
Pea	Food	4	6	2
Peanut	Oil, food	2	3	1
Quinoa	Food	1	6	1
Sesame	Oil	4	5	2
Soybean	Oil, meal	9	10	9
Stokes aster	Manufacturing	4	5	2
Sunflower	Oil	5	6	3
Tobacco	Smoking	3	3	1
Wheat	Food	8	9	7

Note: Agronomic and marketing ratings are based on a 0–10 scale, 0 being the lowest rating possible.

* Derived by multiplying the agronomic and marketing ratings, then dividing by 10 and rounding off.

Drought-tolerant grain sorghum can be fed or marketed in Illinois but does not compete well with corn on better soils.

listed in the table. The recent surge of interest in ethnic foods may create lucrative local markets for some of these crops. Producers should keep in mind, however, that agronomic characteristics and growing-season requirements for some alternative crops may be largely unknown. And the risk of market saturation and competition from low-priced imports may affect the marketing success of such crops. For these reasons, some new crops may be grown on fairly small acreage to start, at least until demand for them increases.

Nevertheless, there seems to be hope that alternative crops can provide new marketing and income opportunities for operators wanting to diversify. The key is to carefully analyze the situation first in order to choose the crop best suited for your situation.

Emerson Nafziger, associate professor of agronomy

Why Not Oats?

Fred L. Kolb
and Charles M. Brown

Over the past thirty years, the amount of oats harvested for grain in Illinois has decreased from about 2 million acres to 200,000 acres. The downscaling of oat production reflects a general decline in the diversity of the state's agriculture during the same period.

Oat acreage continues to decline despite a sharp increase in the demand for oats as a human food over the past five years. The demand for oats for human consumption has in fact doubled in that period.

In recent years, new discoveries regarding the desirable nutritional qualities of oats have made them popular with consumers. For instance, as part of a low-fat diet, the water-soluble fiber in oat bran and oatmeal has been shown to reduce serum cholesterol levels in individuals with high serum cholesterol. Considering the abundance of information available these days about the health risks associated with high cholesterol, the new attention given to oats should come as little surprise.

So, considering the new demand, why are Illinois farmers planting fewer acres to oats? Two major reasons for the drop in oat acreage are the reduced use of oats as livestock feed and the lower net return per acre when compared to other crops grown in Illinois.

Oats is the only grain crop for which the United States is a net importer. In 1989 about forty million bushels of oats were imported into the United States, primarily from Canada, Sweden, and Argentina. The imported oats were generally lower in grain quality and protein percentage than those grown in the United States.

Nutritious products such as oatmeal and oat bran muffins are good sources of water-soluble fiber.

For oats to be a suitable option for Illinois farmers, the economic return to the producer would need to be similar to that of other crops. But the government-guaranteed target price for oats has been low, and government farm programs have generally discouraged domestic oat production.

Increasing oat acreage would help to diversify Illinois agriculture. Oats provide an excellent alternative crop for sloping terrain where the soil is prone to erosion. Oats require low input — the cost of seed is low, and herbicides are usually not necessary. Thus, although gross return is lower for oats than for corn or soybeans, the cost of production is also lower. In some areas, farmers need the straw for livestock bedding, or they may sell the straw for additional income. Oats may also be used as a nurse crop for establishing legumes. Although oats traditionally require low input, yields are increased by proper fertilizer application based on nutrient requirements determined by soil testing.

In Illinois, oats are best suited to the cooler environment of the northern half of the state. Although oat is a cool-season crop, in a drought year like 1988 oats yielded well in comparison to corn and soybeans because the oats matured and were harvested in July before the most severe part of the drought. Therefore, in addition to increasing the diversity of Illinois agriculture, growing oats may reduce the risk of crop failure due to drought and other hazards.

Oat varieties now available produce higher yields and have better disease resistance and grain quality than varieties grown twenty or thirty years ago. Yields exceeding one hundred bushels per acre are common in Illinois. Many improved varieties of oats have been developed at the Illinois Agricultural Experiment Station. They include Ogle, Larry, Hazel, Don, Otee, and Lang. In 1989, 49 percent of the U.S. oat acreage used to produce certified seed was planted to varieties developed at the University of Illinois. The Agricultural Experiment Station's strong program in oat breeding has emphasized improvement in yield, grain quality, and disease resistance.

Considering the increased demand for oats and the crop's potential as an alternative to corn and soybeans in some cases, Illinois farmers should ask themselves, Why not oats? when considering diversifying their farming operations.

Fred L. Kolb, assistant professor of agronomy, and Charles M. Brown, professor emeritus of agronomy

Organically Grown Produce Finding Market Niche

John B. Masiunas and John M. Gerber

Today's emphasis on health and nutrition has prompted an increasing number of consumers to demand fresh produce grown without the use of synthetic pesticides, fertilizers, or growth hormones (Figure 1). In recent national surveys, 28 percent of consumers have sought produce grown either organically or with limited use of chemicals.

The most common organic produce today are tomatoes and apples. In a recent Louis Harris poll, 84 percent of consumers surveyed indicated a preference for organically grown fruits and vegetables if the cost was the same as other produce. Despite the increased demand for organic fruits and vegetables, growth of the industry has been slow.

Organics in Illinois

In a recent survey conducted by University of Illinois researchers, 4.5 percent of the state's fruit and vegetable growers indicated they were organic — that they did not use synthetic pesticides. Fruit and vegetable growers practicing organic methods tend to farm fewer acres than conventional growers.

Organic fruit growers in the state average three acres of fruit, compared to twenty-one acres for conventional fruit growers (Table 1). Most of the organic fruits are either strawberries or brambles (blackberries and raspberries).

The state's organic vegetable growers farm more acres on average than its fruit growers, allowing them to rotate land among different vegetables. They average twelve acres of vegetables, compared to

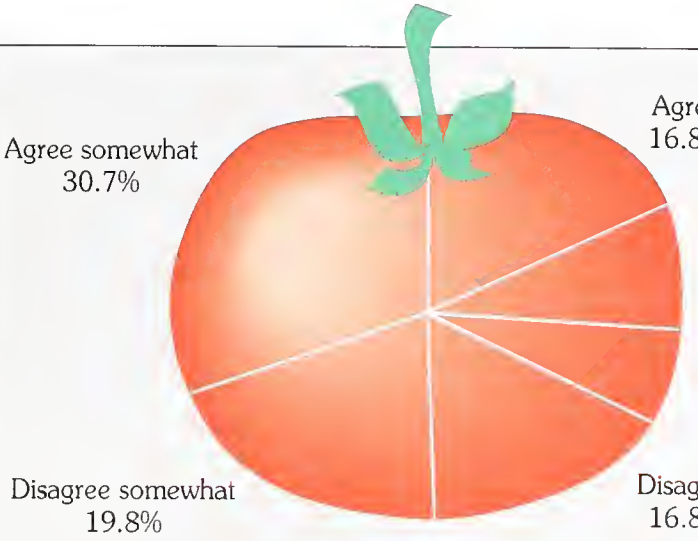


Figure 1. Response of fruit and vegetable consumers to the statement, "Regardless of cost, [I] would rather buy organic produce, grown without the use of chemical fertilizers and pesticides" (from a survey conducted in late 1989 by Market Facts, Inc.).

Table 1.
A Comparison of Organic and Conventional Fruit and Vegetable Growers in Illinois

	Organic		Conventional	
	Total	Average	Total	Average
	acres			
Fruit	26	3	4,395	21
Vegetables	87	12	12,388	66
Total farm	1,881	125	62,614	205

Source: Masiunas, J.B. 1989. *Pest Management in Fresh Market Fruits and Vegetables.* Unpublished survey. University of Illinois.

an average of sixty-six acres for conventional growers. Organic vegetables grown in Illinois include a wide variety, everything from herbs and greens to tomatoes, squash, and peppers.

Organic growers are more likely to substitute on-farm resources for off-farm (purchased) resources than are conventional growers with similarly sized operations. Organic growers tend to use cover crops to improve soil tilth, cultivation and tillage to control weeds, and resistant fruit and vegetable varieties to control disease. In the University survey, organic fruit and vegetable growers indicated that they were especially concerned about soil erosion, contamination of ground water from agricultural chemicals, and pesticide residues in fruits and vegetables.

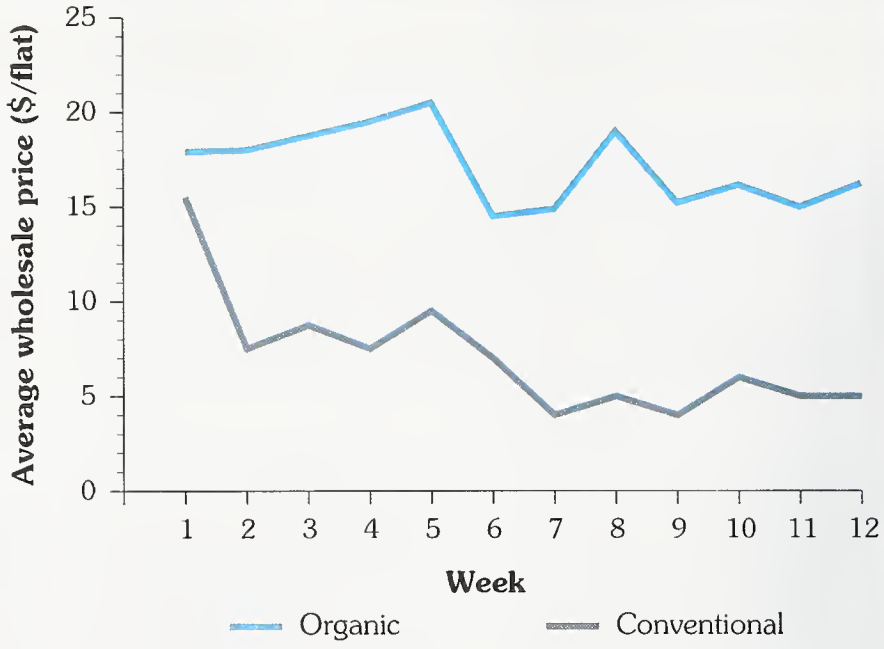


Figure 2. Comparison of the wholesale prices for organically and conventionally grown cherry tomatoes for the period of May 12 to July 28, 1989. The wholesale prices were those of California organic growers (organic) and of the Los Angeles Terminal Market (conventional).

Diversity of the Industry

Organic farming can be found in every region of the state, from the counties surrounding Chicago to Union County in southernmost Illinois. The crops grown and the marketing methods used to sell them are also very diverse.

Mike Michael owns Ladybug Farm, located in Spring Grove, near Chicago. Mike insists on delivering top-quality, farm-fresh organically grown herbs and vegetables to his customers. Emphasizing specialty items, he grows seventy varieties of greens and herbs. Ladybug Farm is renowned for its vine-ripened tomatoes. They are not the hard, flavorless varieties that have become the standard in grocery stores. Instead, Michael grows older, flavorful varieties such as Lemon Boy, Roma, and Valencia.

Ladybug Farm employs a unique marketing system. From the farm's establishment in 1982, its reputation for excellence has spread by word-of-mouth among restaurateurs. Today the company delivers fresh vegetables to a network of sixty Chicago-area restaurants five days a week. A half-dozen supermarket chains also sell Ladybug Farm products. To build retail customer loyalty, Ladybug Farm stickers are placed on each tomato fruit sold. It is now commonplace for customers to ask for Ladybug tomatoes by name, even after the season is over.

Another farmer, Stephen Smith of Pumpkin Hollow Farm, illustrates the diversity of the organic growers in Illinois. Like many others in the back-to-the-land movement of the 1970s, Steve left New York City in search of something that he felt was missing in his life. He found that elusive "something" in Anna, a rural community south of Carbondale. He has been farming in southern Illinois for twelve years now.

At Pumpkin Hollow Farm, Smith produces organically grown tomatoes, sweet corn, bell peppers, squash, leafy greens, onions, and more. He starts planting in February; begins harvesting greens in May; and is still selling pumpkins, squash, and sweet potatoes at the Carbondale farmers' market at Thanksgiving. The multiple plantings and intensive culture on his ten-acre farm keep food on his table year-round and ample supplies to sell at the market.

Unlike Mike Michael, Smith has seen his restaurant clientele dwindle over the years. When he started in 1977, his

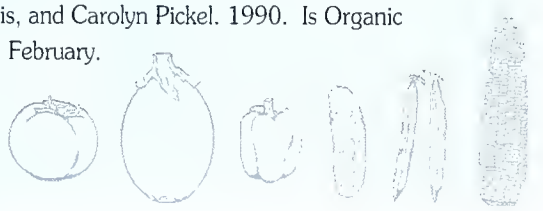
Love Apple Goes to Court

Whether the tomato is a fruit or a vegetable is a classic horticultural question. Technically it is a fruit because it develops from an ovary. But it traditionally has been treated as a vegetable. Even the highest court in the land has had to grapple with this question. In 1893 the U.S. Supreme Court ruled, "Botanically speaking, tomatoes are the fruit of a vine...but in the common language of the people, they are vegetables."

Table 2.
Prices and Per-Acre Net Returns from Organic and Conventional Produce

Crop	Price per pound		Net returns per acre	
	Conventional	Organic	Conventional	Organic
	dollars			
Tomatoes	0.24	0.35	2,862	2,090
Eggplant	0.17	0.29	2,369	3,520
Peppers	0.17	0.34	187	1,218
Cucumbers	0.13	0.22	1,760	2,820
Snapbeans	0.21	0.35	193	191
Sweet corn	0.09	0.14	(-20)	(-150)

Source: Cook, Roberta, Kim Norris, and Carolyn Pickel. 1990. Is Organic Production Profitable? *The Grower*. February. Pp. 38–42.



clients included a number of small mom-and-pop establishments serving the students at Southern Illinois University at Carbondale. But many of those small establishments had to close their doors to business after the fast-food franchises came to town. And the fast-food franchises do not buy locally grown organic vegetables. So Steve now relies on farmers' markets, where he has built customer loyalty, to sell the fruits of his labor.

Limits on Growth of Industry

Three factors have restricted growth of the organic fruit and vegetable industry in Illinois. First, organically grown fruits and vegetables cost more than other produce, making them less attractive to consumers, especially middle-income and limited-income families (Table 2 and Figure 2). Organic production methods are more labor-intensive than conventional methods. The New Alchemy Institute in Falmouth, Massachusetts, estimates that of the total production costs for growing organic tomatoes, 50 percent goes toward labor. By contrast, labor accounts for less than 20 percent of the cost of conventional tomato production.

Another variable elevating the price of organic produce is the higher culling rates necessary for maintaining quality comparable to that of conventionally grown produce. The higher labor costs and greater culling rates often reduce the net return per acre for organic growers (Table 2).

A second factor limiting growth of the industry is the extreme price fluctuations characteristic of specialty agricultural products. Often, organic fruits and vegetables drop in price during the summer because of the high availability of locally produced and home-grown products. In the winter, prices may soar because of short supplies and long shipping distances. Consistent quality can also be a problem, since organic produce is often picked fully ripe and therefore has a shorter shelf life.

A third limitation is the lack of federal and state standards defining what is organic. Senator Patrick Leahy of Vermont and nineteen other senators have sponsored the Organic Foods Production Act to establish national standards for production of organic products and to standardize labeling.

Efforts are also under way to develop state labeling laws. In Illinois, organic growers have been working on an organic foods labeling act to assist in achieving product differentiation and to prevent potential fraud. Organizations involved in the effort include the Land of Lincoln Organic Growers Association, the Illinois chapter of the Organic Crop Improvement Association, the Illinois Consumers for Safe Food, the Illinois Stewardship Alliance, the Illinois Department of Agriculture, and the Illinois Specialty Growers Association.

Marketing Organics in Illinois

A traditional source of organic fruits and vegetables has been natural food stores and cooperatives. Natural food stores are generally found in larger Illinois cities, and some have handled organic produce for more than twenty years. This long-term commitment has allowed them to establish extensive networks of sources within the organic food industry. Many natural food stores and co-ops now stock a wide variety of quality fruits and vegetables. Gone are the early days of organics, when farmers could offer food stores only a narrow selection of poor-quality fruits and vegetables.

Green Earth in Evansville offers an innovative approach to natural-food retailing. Co-owned by Kyra Walsh and Karin Dittmar, Green Earth is not only a large food store but also a mail-order business carrying a full line of organic fruits and vegetables. During the summer, the business partners buy directly from local growers. At other times, they buy produce flown in from California. Walsh and Dittmar research their Illinois growers carefully, using questionnaires and visits to get to know them and their operations better.

Mike Michaels of Spring Grove delivers fresh vegetables to Chicago-area restaurants five days a week. (Photo courtesy of Ladybug Farm.)

Terminal markets and produce wholesalers have been an important source of conventionally grown fruits and vegetables. An increasing number of wholesalers in Illinois also specialize in organics. One example is Midwest Organic Produce, owned by Maurice Dayan. Since 1988 the company has operated out of the South Water Market, the terminal fruit and vegetable market in Chicago.

Much of Midwest Organic Produce's business is done with health food stores and co-ops, Chicago's more progressive and cosmopolitan niche grocery stores, local wholesalers, and trendy restaurants. To ensure a year-round supply of organic fruits and vegetables, they buy produce from the West Coast, Texas, and Florida.

Most consumers shop for produce in retail grocery stores and supermarkets. Some grocery stores in Illinois have attempted to stock organic items, but their efforts have not always been successful. It has been difficult for supermarket chains to find consistent quantities of organic products or to encourage customer recognition of organics. Thus, supermarkets generally have lagged behind smaller retail outlets in stocking such items.

Rosalie Ziomek, executive director of the Illinois Consumers for Safe Food, contends that for organic foods to become an important segment of the marketplace, large supermarket chains will have to routinely handle them. She advises consumers to use the power of the shopping cart to demand organic produce. If this effort is successful, the small market niche organics now occupy could become a major boon to Illinois agriculture.

John B. Masiunas, assistant professor of horticulture, and John M. Gerber, professor of horticulture and assistant director of the Agricultural Experiment Station

Tailor-Made Tomatoes

Charles E. Voigt and John A. Juvik

During the past twenty-five years, tomato marketing has greatly diversified based on end-product use. Today's increased marketing alternatives have prompted the development of specific varietal types genetically designed to satisfy the various consumer market segments.

Researchers at the University of Illinois are involved in the effort to develop new and improved tomato cultivars. These scientists are examining wild genetic resources and cultivated tomato varieties to survey for existing types that could fill specific market niches. In addition, they are working to identify individual transferable traits that can be used to improve the quality or versatility of varieties already well suited to market demands.

Plant breeders in the United States have developed specialized tomato varieties suitable for processing and canning, fresh-market sales, or the home garden. The greatest proportion of the nation's tomato acreage is grown for processing. These tomatoes are machine-harvested at the red-ripe stage, then either canned whole or pureed and partially dehydrated to produce juice, sauce, paste, and ketchup.

Recent research at the University has focused on increasing fruit-soluble solids, composed primarily of sugars, organic acids, and proteins. These solids represent 60 percent of the tomato's dry weight. With a higher soluble-solids content, net yield and fruit quality increase while costs for dehydration decrease.

Commercial fresh-market tomatoes constitute another significant economic niche in tomato production. Generally, these tomatoes are harvested by hand just prior to displaying the red pigment associated with ripening. They complete ripening during shipment. Fresh-market

breeding work is aimed at developing varieties with uniform shape, size, color, and flavor. Scientists at the University are studying the feasibility of using a parthenocarpic gene that induces seedless fruit. Studies have shown that these parthenocarpic fruit can develop without pollination. They are therefore less sensitive to extreme environmental conditions known to inhibit pollination.

With home-garden tomato varieties, insect and disease resistance as well as taste and growth habit are important. University researchers, in conjunction with the Monsanto Company, are investigating the potential use of tomato plants containing a gene from *Bacillus thuringiensis* that confers improved resistance to insects. Tomato genotypes have been genetically engineered to contain and express this bacterial gene, which can synthesize a protein highly toxic to a number of species of insect pests but is harmless to humans. Greenhouse and field tests suggest that these genetically engineered plants possess sufficient resistance to allow for the reduction or elimination of insecticidal sprays, thus improving consumer safety and reducing grower production costs.

Wild Species
and Early Landraces Developed
by Pre-Columbian Civilizations
in South and Central America

⇓

Introduction into Europe
and North America

⇓

Development of Landraces
and Older Varieties
Adapted to Temperate Climates

⇓

Use of Genetic Diversity
to Create Specific Marketing Types
by Modern Breeding Technology

Figure 1. Tomato genetic variation.

Very recently, a specialized commercial market has developed for novelty tomato types. The more distinct the tomato's color, shape, size, and taste, the greater its appeal to curious consumers. To try to identify material that might expand the tomato market further in this direction, surveys are being conducted at the University on a large number of older "heirloom" varieties. This research is being done in cooperation with the Seed Savers' Exchange. The varieties being evaluated include tomatoes from the size of garden peas to much larger fruits weighing several pounds. Also being evaluated are tomatoes with variations in color — from red, yellow, orange, and green (when ripe) to white, pink, and purple.

To successfully compete for an expanding share of the consumer market, all agricultural commodities must diversify their end-product use. In the case of the tomato, the genetic diversity created in the past and maintained by our ancestors has fueled the development of varieties tailor-made for today's specialty markets.

Charles E. Voigt, research specialist in agriculture, and John A. Juvik, associate professor of plant genetics, Department of Horticulture

The tomato genus Lycopersicon, *native to South America and Central America, includes eight species, all of which can be hybridized with the cultivated tomato,* Lycopersicon esculentum. *The result is a large wild gene pool available to plant breeders interested in developing new and unique genotypes to fill new market niches. Although wild ancestral tomato fruits were only the size of peas, selection and domestication by pre-Columbian agriculturists and later development in Europe and North America have created an array of types and sizes with amazing genetic diversity. These subspecies, varieties, and landraces have been a valuable legacy for twentieth-century breeding programs. (Photo courtesy of Charles Voigt.)*

Policies to Create Diversity in Illinois Agriculture

Harold D. Guither

Farmers are becoming increasingly interested in diversifying their agricultural operations. Meetings, conferences, and exhibitions focusing on new and alternative farm enterprises have become popular and well attended. But whether interest can be shifted to action depends on the economics of changing enterprises and the public policies that will encourage or discourage such decisions.

What the Farmers Think

In February 1989, a group of agricultural economists from twenty-one states cooperated in a nationwide survey of farmers' preferences concerning federal agricultural and food policies. The survey, sponsored by the National Public Policy Education Committee, provided valuable information on farmers' concerns regarding the Food Security Act of 1985 and the new 1990 farm bill. One thousand Illinois farm operators participated in the survey.

The survey results indicated a willingness on the part of Illinois farmers to diversify their farm operations. Twelve percent of the Illinois farmers surveyed reported having grown new crops or started some new livestock, poultry, or other enterprise some time in the previous five years. Among the new enterprises reported were crops (49 percent), livestock or poultry (40 percent), and services (11 percent). Thirty-four percent said they would produce a new crop in 1989.

Current farm programs and policies affect farmers' desire to grow new crops or start other money-making enterprises. When asked whether more flexibility in farm program acreage rules would encourage them to grow new crops or start other enterprises, 37 percent of the Illinois farmers surveyed said yes.

Policies that provide help to farmers who want to try new farm enterprises could encourage more agricultural diversity. Table 1 lists the kinds of help farmers need most to diversify their operations.

Table 1.
Help U.S. Farmers Need Most to Start New Enterprises

	percent
Research-backed information on cultural practices	62
Contract or dependable firm to buy the product	50
Low-interest loans to finance new crop or enterprise	44
Farm program that permits growing new crop without loss of acreage base for program crop	31
More information on production costs	19
Commodity price support loans	2

Source: University of Illinois. July 1990. *New Agricultural and Rural Enterprises for Illinois Farmers.* AE4666. Department of Agricultural Economics, College of Agriculture, Agricultural Experiment Station.

The Policy Maker's Role

The responses of farmers participating in the survey indicate that they have explored the idea of diversification and that many are receptive to change. Implementing certain policies at both the state and federal levels could accelerate farmers' decisions to diversify.

One of the most important areas for policy makers to consider is public funding for continuing-education and research programs. Farmers interested in starting new service enterprises, for example, need to acquire knowledge of business management. They also benefit from talking with peers and experts with knowledge of the subject. Cooperative Extension classes, meetings, and field demonstrations are all part of farmers' continuing education.

Farmers wanting to diversify their operations would also benefit from research on the most efficient and profitable methods of production for new crop, livestock, and poultry enterprises. Without thorough knowledge of cultural and management practices, new enterprises pose high risks. Farmers are not likely to try something new unless they see a potential for success.

Raising vegetable crops may be a means for some Illinois farmers to diversify.

In the survey, farmers said they would prefer to sell a new product under a contract or have dependable buyers. To enhance efficient marketing, new policies could establish grade standards for new crops, livestock, or poultry; publish market price information; develop supply-and-demand estimates; and assist with export market development if the new commodities have international market potential.

Low-priced credit could encourage diversity where capital is required to implement a new enterprise. Current policies would allow lower-cost credit from the Farmers Home Administration for those farmers who could not get credit from other sources. Usually Farmers Home Administration loans require a lower interest rate and are offered to young farmers. A policy to encourage loans for new farming enterprises might stimulate the diversification process.

Farm Subsidies and Program Crops

Farm commodity programs have encouraged production of program crops for which a target price, loan rate, and deficiency payment are established. The acreage bases encourage continued production of the program crop because of the potential deficiency payment. Failure to maintain production on the crop acreage base has in the past resulted in loss of part of the crop base.

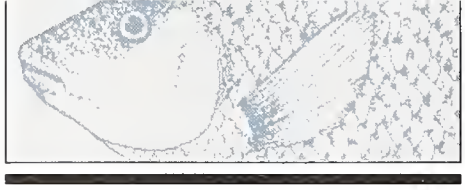
Now flexibility has become the buzzword in farm policy reform. The 1988 Disaster Assistance Act permitted farmers to plant part of their crop base acreage to soybeans or sunflowers. In Illinois, this meant substitution from part of the feed grain or wheat base. But farmers who made a substitution would not lose the historic record of corn or wheat base. A similar substitution was permitted in 1990. Flexibility has also made it possible for other nonprogram crops to be grown on program crop acreage bases. The early experience with this flexible approach suggests that some farmers will take advantage of this substitution opportunity, but market prices also influence these decisions.

The 1990 farm legislation is expected to include some flexibility features that permit farmers to diversify their cropping program without loss of the historic crop acreage base that they regard so highly as insurance for the future if large acreage reduction programs are required.

Detailed production costs might help farmers determine whether they have a chance for a profit on a new crop or livestock enterprise. Special grants could be given to develop this kind of detailed data.

If farmers are to diversify their operations, public policies must be compatible with these changes. Policies can either encourage or discourage the movement toward diversity. For every policy decision there is a consequence. If the desired policy goal is to encourage diversity, then some of the policy decisions discussed here must be made to help facilitate this goal.

Harold D. Guither, professor of agricultural policy, Department of Agricultural Economics



Meat Industry Caters to Consumers

Peter J. Bechtel and Floyd K. McKeith

Americans are changing their eating habits, reflecting a new emphasis on health and fitness. As a result, the food industry is offering more diverse products to fit the new lifestyles of consumers. In the Illinois meat industry, the trend has been toward expanding the number of products within the traditional beef and pork sectors along with introducing other animals, such as fish and poultry, to satisfy our increasing appetite for diverse foods.

Illinois Animal and Meat Industries

The increasing diversification of domestic food animals in Illinois reflects what is happening nationwide. The major species in Illinois are hogs, cattle, horses, chickens, turkeys, and sheep.

Major meat animal species and their values are shown in Tables 1 and 2. In terms of both numbers and value, the pig is the state's dominant meat animal. Although hog numbers have decreased during the past decade, cash receipts have remained rather constant. During the same period, cattle and calf numbers have decreased, though cash receipts have increased. The sheep and lamb industry has been relatively static during the past decade.

An often-overlooked component of the state's animal industry is the horse. The Illinois horse population, numbering around 150,000, has remained steady during the past five years. The species is important for a variety of reasons, one being that they consume large quantities of locally produced feed. They are also valued as pleasure animals (riding and racing) and draft animals. To a lesser extent, they are used for milk, meat, and leather. The horse industry is a significant component of the state's total farm animal enterprise.

A large number of minor species fill niche markets in Illinois for both meat and other uses. An active rabbit industry provides meat for specialty restaurants. A small but thriving goat industry provides milk and meat. Game farms produce deer and buffalo meat. The state also produces fish, crayfish, bees, laboratory animals, llamas, mink, and fox.

Aquaculture is an active and growing segment of the animal industry. Once restricted to warmer climates in the United States, the industry has now expanded northward. The producer-oriented Illinois Aquaculture Association was recently formed to help guide and monitor the industry within the state. Fish grown in the state include sea bass, catfish, and tilapia (tropical freshwater fish resembling sunfish). The state has also spawned a small crayfish industry.

Table 1.
Illinois Farm Animal Numbers

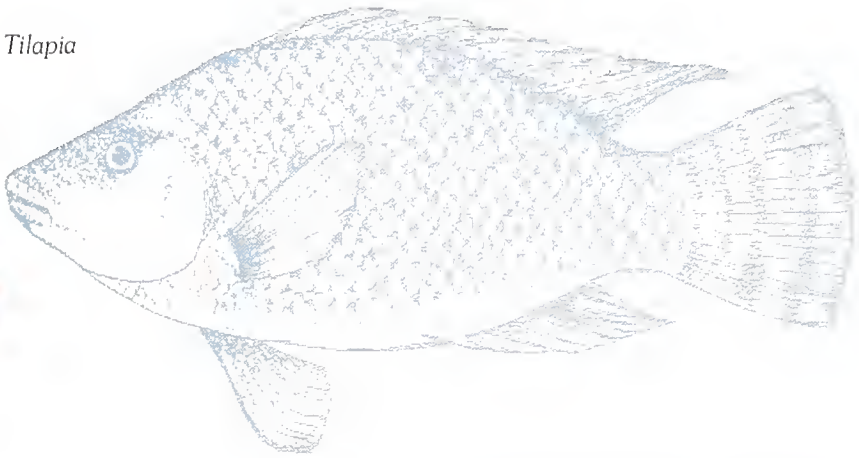
	1979	1984	1989
	thousands		
Hogs	6,550	5,400	5,600
Cattle and calves	2,850	2,600	1,950
Sheep and lambs	184	145	140

Source: U.S. Department of Agriculture as listed in *MeatFacts* (1979, 1984, and 1989), published by the American Meat Institute.

Table 2.
Illinois Cash Receipts for Meat Animals

	1978	1983	1988
	millions		
Hogs	$1,091	$1,124	$1,024
Cattle and calves	702	745	812
Sheep and lambs	6	6	6
Total	1,799	1,875	1,842

Source: U.S. Department of Agriculture as listed in *MeatFacts* (1979, 1984, and 1989), published by the American Meat Institute.



Tilapia

A recent trend in the non-meat animal industry has been an increase of exotic species. An example is the llama, sold at auction centers in a number of states. In Illinois and elsewhere, mink and fox ranches supply the fur industry.

Also worth mentioning is the insect sector of the animal industry. Bees are used for pollination and production of honey. And insects for biological control of crop pests have become a reality.

Meat Product Diversity

Changes in meat consumption in the United States are shown in Table 3. The trend toward diversification can be readily seen in the number of products targeted to different market segments. Many of these products are "branded," which means they are labeled and promoted by a company. This concept is quite old for processed meats such as frankfurters, sausages, and luncheon meats. Fresh red

Table 3.
U.S. Per-Capita Consumption of Red Meat, Poultry, and Fish

	Boneless equivalent		
	1968	1978	1988
	- - - - - - - pounds - - - - - - -		
Beef	77.3	82.3	68.6
Pork	49.4	40.4	44.7
Chicken	25.4	32.1	44.3
Fish	11.0	13.4	15.0
Turkey	6.4	7.2	12.8
Veal	2.6	2.0	1.2
Lamb	2.4	1.0	1.0

Source: U.S. Department of Agriculture as listed in *MeatFacts* (1989), published by the American Meat Institute.

Aquaculture is an active and growing segment of the Illinois meat industry.

meats, however, have traditionally been cut by local butchers and sold as a kind of commodity. Thus, branded fresh meat is a relatively new concept. It should be pointed out that fresh poultry is often sold under a brand name (Holly Farms, for example). With the identification of unique markets for fresh meats, a number of new products have been tailored to fill these niches.

Meat producers are using several strategies to market fresh beef. One successful venture has been the Certified Angus Beef program, which has targeted the upscale market with a high-quality, tender, traditional beef. Sales of Certified Angus Beef have shown good growth and have strong consumer, restaurant, and export markets.

The diet and health markets have also been targeted for unique branded beef products. One segment of this group uses labeling claims to promote the nonuse of hormones, antibiotics, and growth stimulants. Several examples are Coleman's Natural Beef, Ranch Connection Beef, and Natural Lite Beef. It should be noted that several companies are emphasizing hormone- and antibiotic-free poultry as well.

Brand-labeled meats containing reduced calories per serving are also being marketed. The U.S. Department of Agriculture monitors and controls the use of claims on meat products such as "lite" or "extra lean." Brand names such as Key-lite and Laura's Lean Beef are examples of beef merchandised for consumers wanting quality, low-fat fresh meats. Some supermarket chains are providing fresh meat products with lower fat contents by purchasing meat with less marbling and removing more fat during trimming. During the past ten years, the pork industry has produced lower-fat products such as 95 percent fat-free ham and low-fat luncheon meats.

Convenience-oriented meat products are also entering the marketplace. A number of companies, including Excel and Hormel, are producing closely trimmed "individual" meat portions packaged in vacuum containers. These "peg-board" packages have an extended shelf life when refrigerated and provide individual portions. Also, because the product is packaged at a centralized meat cutting facility, the store does not have to employ a meat cutter. A number of other companies are also producing precooked and microwavable steaks and roasts. Companies such as Con Agra, Bryan Foods, Bil Mar Foods, and Kroger are exploring new ways to exploit the growing markets for precooked and microwavable products.

An interesting trend in the food industry has been the marketing of ethnic food products. The meat industry has played a major role in this development by providing unique products to meet the demands for many colorful and flavorful ethnic cuisines. Scaloppini slices, stir fry meats, Italian sausages, bratwurst, meat for gyro sandwiches, and smoked goose wings are but a sampling of the diversity in ethnic meats.

Turkeys Take Off

Ken W. Koelkebeck

U.S. turkey production and consumption are up and have been for some time. And local producers wisely have involved themselves in this growth industry.

According to the Illinois Agricultural Statistics Service, the 1989 value of production (based on a market price of $0.40 per pound) for the state's turkey industry exceeded $34 million. That was more than double the previous year's figure.

By increasing production, turkey growers have simply responded to the demands of the market. Total U.S. turkey consumption has increased dramatically over the past ten years. In 1980, 2.5 billion pounds of turkey was enough to satisfy our appetite for this meat. By 1989 that figure had risen to 5 billion pounds.

As our society grows increasingly health conscious, it is not surprising that more and more people are making turkey part of their regular diet. An excellent source of protein, turkey contains less total fat and calories than beef, pork, or lamb (Table 1). Per-capita consumption of turkey has risen from 10.5 pounds in 1980 to 16.9 pounds in 1989.

Besides being nutritious, turkey is a versatile food. Its uses range from the traditional whole bird for Thanksgiving dinner to ham, pastrami, bologna, bratwurst, and ground turkey (a good substitute for ground beef).

Responding to increased turkey consumption and a forecast for this trend to continue, turkey companies across the country have stepped up production over the past five years. During this time, Illinois turkey production has jumped from about 350,000 to roughly 3.7 million birds per year.

Two major companies, along with a few independent growers, now raise turkeys in Illinois. The biggest are Trevcam, Inc., and Perdue Turkey Farms. In terms of production, the largest of the two is Quincy-based Trevcam, which produced roughly 2.7 million turkeys in 1989 on about fifty contract grow-out farms. Perdue, based in Indiana, contracts out to about thirty growers in Illinois, mainly in Lawrence County, on the Indiana border. Its Illinois production amounts to approximately 1 million birds annually.

A number of factors have contributed to the dramatic growth in the state's turkey industry. These include a surplus of feed grain (corn and soybeans); a favorable growing climate; an availability of adequate land; a close proximity to retail markets (Chicago, St. Louis, and Indianapolis); and a good highway transportation system. The growth has occurred despite some significant drawbacks, such as a negative attitude of some farmers and lending institutions about the industry's viability; farmers'

Although a small number of turkeys are raised "on range" as shown, most are produced in confinement.

general unfamiliarity with contract production; and the state's relatively high tax and workers' compensation rates.

Illinois farmers who have decided to grow turkeys on contract for major companies have found it to be an effective way to diversify their farming operations. Considering the many advantages the state offers for poultry production, combined with the prospect of an increasing demand for turkey products, the outlook appears to be bright for local turkey farmers.

Ken W. Koelkebeck, poultry Extension specialist

Table 1.
Nutrient Values for Turkey, Lamb, Beef, and Pork

	Calories	Fat	Protein	Cholesterol
	per 3-ounce cooked serving			
Turkey	129	2.6 grams	25 grams	64 milligrams
Lamb	176	8.1 grams	24 grams	78 milligrams
Beef	192	9.4 grams	25 grams	73 milligrams
Pork	198	11.1 grams	23 grams	79 milligrams

Source: U.S. Department of Agriculture.

Consumer Diversity

It has been apparent for a number of years that meat products can be successfully targeted to different groups of consumers. One clear trend in our society is the aging of the population, which will have an impact on meat purchases. The increase in the number of elderly will result in smaller households, smaller mealtime meat portions, greater health and nutrition concerns, and in many cases more disposable income to spend on quality and convenience-positioned products.

Over the last several years, on-the-go and health-oriented consumer segments have also increased, while the number of "meat lovers" has dwindled. Many producers are following changes in consumer preferences to effectively target their products toward specific market segments.

As a major red-meat producer and food and meat processing center, Illinois must continue to provide a wide array of products to satisfy the many consumer markets both here and across the nation.

Peter J. Bechtel, former professor, and Floyd K. McKeith, associate professor, of animal sciences*

* Now professor and head of the Department of Food Science and Human Nutrition, Colorado State University.

Specialty Meats

Tina Prow

Every food store carries meat, but few offer the service shoppers get at Thrushwood Farms Quality Meats, Inc., in Galesburg. And none carries Thrushwood Farms' award-winning hams.

"In order to compete, we have to have a product that's better and special service to go along with it," says Jim Hankes, who runs Galesburg's only complete meat operation with his wife, Kay. "For instance, we've got a good reputation for what we do with pork. Our hams are mild-cured, without water or juices added. They've taken state and national awards, and people just go wild over the cuts we serve in the catering line.

"You just can't buy that kind of ham in stores anymore."

On opening day in 1978, the Hankes filled their meat cases with fresh-cut beef and pork, not expecting to offer much beyond custom butchering. Today, however, things are different. With sales of more than $1 million annually, Thrushwood Farms retails, wholesales, and custom-butchers meats. A deli area is stocked with an array of sandwich makings, salads, and cheeses. A freezer holds seafood, fruits, and some meats. The selection on a full-service catering menu ranges from meat and cheese trays to sandwiches and sausages to ribeye steaks and hog roasts.

"In 1978, we weren't concerned about specialty markets. But we lost some markets and looked around for new ones," Jim says. "We gradually added more service, equipment, and showcases. The specialty store just evolved and grew with the markets we found."

Those markets are built on customer demand for services and products no one else offers, he says. But filling customer demand is only part of the Hankes family's strategy for growth. They also work at creating demand among Galesburg's thirty-five thousand residents. The shop offers samples and sales specials to entice customers to try new foods. And aggressive advertising campaigns let people know where they can find specialty catering, "the best Easter hams," and meats that will make them "cookout kings."

"You have to stay visible in your market, and word-of-mouth only takes you so far. We saturate the market, use repetition to let our customers know we're still out there, ride on our laurels for a while, and then hit again.

"It's difficult to spend money on advertising because the results are so hard to measure. But it's necessary," Jim says. "You might have the right equipment and technology and put out a good product, but if you don't sell that product, you won't get very far."

The Hankes credit some of the success of Thrushwood Farms to education and preparation that made for a solid business foundation. A job at the University of Illinois meats lab gave Jim real-world experience while he earned a bachelor's degree in animal science and a master's in meat science. Kay's course work for a bachelor's degree in home economics education, also at the University, proved to be vital when the business added deli and catering markets.

Before breaking ground for the business, they researched demographics, created an ideal meat plant on paper, investigated costs, and worked with an accountant to put together a five-year business plan.

Even after being in the business more than a decade, they still attend seminars, workshops, and meetings to stay current with new developments, ideas, and trends. This year, Jim is president of the American Association of Meat Processors.

"We're bigger than we ever imagined we could be, and there is potential to expand even further," he says. "We've evolved and grown because with our knowledge we can take a product and make it better. That's kind of fun."

Tina Prow, Extension communications specialist

Owner Jim Hankes displays a Thrushwood Farms award-winner. (Photo courtesy Thrushwood Farms)

Illinois Agriculture in Transition: An Ecological Perspective

Richard E. Warner

The American public is becoming increasingly aware of and concerned about modern agriculture's effect on the environment. The Food Security Acts of 1985 and those pending for 1990 reflect the non-farm sector's heightened involvement in such environmental issues.

To understand the dynamics underlying this new public concern, one must look at the history of U.S. agricultural ecosystems and the way in which farmers have interacted with their land resources.

Historical Patterns in Agricultural Ecosystems

Illinois, especially its central counties, has been a leader among states in the adoption of new farming methods and technologies. From an ecological perspective, the prairie state has been in the eye of the storm — an environmental storm of sorts — because many modern farming practices have profoundly altered natural ecosystems. In short, Illinois has been a bellwether among the most intensively cropped regions of the world.

There is little doubt that human settlement greatly changed the face of Illinois; by 1980 only 0.5 percent of the state's vegetation remained relatively pristine. Consequently, the rate of plant and animal extinctions has been significant. For example, about 1 percent of the world's 9,000 bird species have become extinct, but a much higher percentage of the avifauna of Illinois has been lost. In fact, since the early 1800s about 5 percent of the fishes, birds, and mammals in Illinois have been exterminated, and another 15 percent of these species are now listed as endangered or threatened.

Illinois agriculture has always been dynamic, and from an ecological perspective these changes fall into three relatively distinct periods. The first, from the mid-1800s through the early 1900s, encompassed settlement farming and emerging agriculture. Presettlement Illinois had several ecological regions that were unique with respect to climatic gradients, geology, soil morphology, flora and fauna, and land forms. However, the more subtle differences in flora and fauna among regions had already diminished in the late 1800s as agronomic practices associated with a developing commercial agriculture became standardized. By 1920 precious little prairie had escaped draining and plowing.

Although settlement had dramatically affected vegetation in Illinois by the late 1800s, grasslands remained common during the era of diversified commercial farming that persisted from the early 1900s through World War II. During this period, forage crops — primarily introduced grasses and legumes — were integral to rotation farming, the production of livestock, and the seeding of fields periodically diverted from production by farm programs. Many prairie vertebrates survived and even thrived in the patchwork of small farms with forage crops and cereal and feed grains in rotation.

After World War II, the era of small, diversified commercial farming came to a close, and the third period of relatively large-scale specialized farming followed. This change-oriented era has been marked by an ever-expanding array of technological innovations. From an ecological standpoint, these changes are responsible for unprecedented chemical and mechanical perturbations of farm landscapes. The diversity and abundance of terrestrial plants and animals have taken yet another turn for the worse.

Changes in aquatic environments have been no less dramatic, as agriculture continues to alter the physical and chemical characteristics of streams, bottomland lakes, and rivers. Indeed, as high rates of sedimentation have occurred, the links between terrestrial and aquatic ecosystems have become increasingly apparent.

Thus, the contemporary farm landscapes of Illinois have become harsh environments for most native flora and fauna. The agricultural practices that have become widespread since World War II have further minimized distinctions among the ecological regions of Illinois. Relatively few native plants and animals are now abundant, and many of those that responded positively to farming are now subject to few natural checks and balances. They often require sustained human intervention to keep them from becoming economic pests.

Post–World War II farming methods have also acutely affected the pathways by which nutrients and energy are transferred to living organisms, and in terms of energy investment those pathways are highly inefficient. On the other hand, the pathways by which energy from the sun was stored and transferred in the prairie

ecosystem — food webs that included a diversity and abundance of soil microbes, plants, invertebrates, and vertebrates — have gradually fallen apart. In terms of biomass produced per unit of energy, modern farming systems are again inefficient because they depend on chemical fertilizers and pesticides that require large investments of petroleum-based products and energy during manufacture. These phenomena are, of course, integral to discussions of sustainable agriculture.

Ecologically Based Transitions

As far back as the mid-1800s, some indicators foretold of environmental upheaval in Illinois's future. The first census of agriculture in the United States, taken in 1850, documented that central Illinois had the highest farmland prices in the nation. Before agricultural settlement was complete, the state's deep, dark prairie soils were appreciated in the marketplace for their great agronomic potential.

Over the years, high land prices and high expectations have motivated Illinois farmers to maximize production. At times this desire to push production to its limit has jeopardized the land's long-term sustainability. As a result, a significant amount of topsoil has been lost, irreplaceable wetlands have been drained, a variety of wildlife habitats has been eliminated, and streams have been chemically and physically altered. Further, farm programs over the decades have not been able to stop the degradation of natural resources. In fact, these programs have often encouraged more intensive cropping.

Long-term patterns of change in farming reflect fundamental interactions between farmers and the land resource, governmental intervention through policies and programs, changing technologies, shifting farm economies and agricultural infrastructures, and the inherent uncertainties of weather and life itself. Indeed, an emphasis on survival has colored the relationship between farmers and the land in different ways at different times.

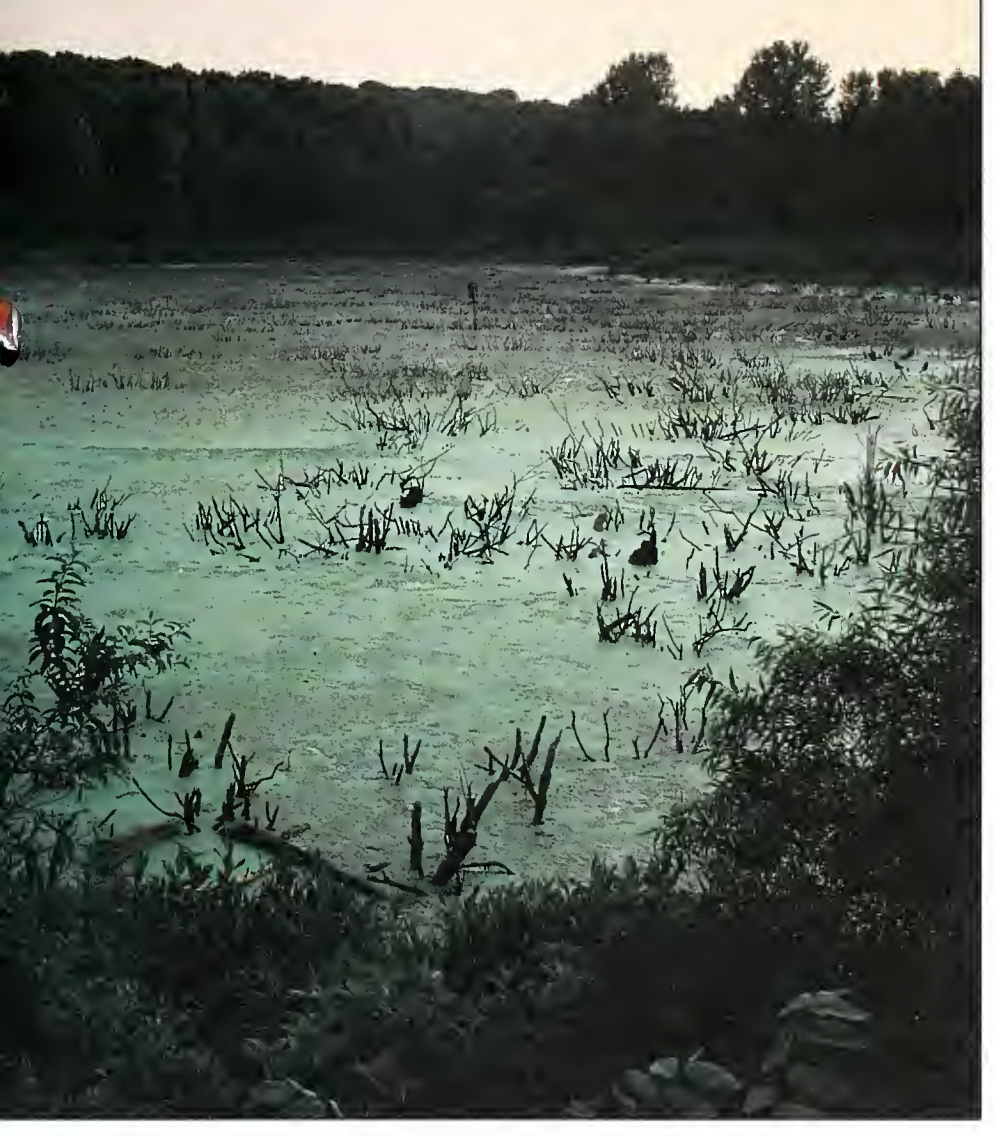
Especially for pioneer farmers, physical survival was preeminent. Given that about half of the children in midwestern farm families of the mid-1800s died before reaching puberty, this emphasis is not surprising. Frontier farmers viewed many animals as vermin. And prairie wetlands with their profuse insects were considered a threat to human health and prosperity. With such innovations as the window screen and the plow, settlers after the Civil War wasted no time in conquering the prairie.

Prairie aquatic environments such as this wetlands have been threatened by agriculture ever since the pioneer days.

By the late 1800s and early 1900s, economic survival became the critical issue, and the period was marked by periodic crop failures and an economic depression. During the 1900s, the farm sector instinctively directed attention to coping with "boom-and-bust" markets and innovations related to profit. Few really grasped the ecological implications of changing land use.

Looking back, we now recognize that the ecosystems that created Illinois's rich prairie soils, an agricultural marvel, no longer exist. Farm landscapes have changed so dramatically from one generation to the next that Illinoisans now have little awareness of, or appreciation for, how these ecosystems once functioned. Nor do they understand those ecosystems' potential for harnessing energy from the sun.

At this point in time, members of the farm community cannot agree on how to create a stewardship of the land, partly because the fundamental properties of ecosystems seem so remote. To some, a "land ethic" means all-out production to



feed a hungry world. At the other extreme, some farmers are frustrated because of the limited resources available to encourage the preservation or restoration of such natural resources as topsoil, pristine streams, and wildlife.

Regardless of where given farmers stand on issues such as full production versus topsoil for their grandchildren, day-to-day constraints of economic survival play short-term profits against long-term, ecologically sound farming practices. Precisely at this tension point, signals from society have been mixed.

Society as a whole — and its farm policies and programs in particular — has contributed to a disjointed approach to the management of land and water resources. For example, the federal government for decades has offered programs to subsidize (encourage) the channelization of streams, thus destroying many of their natural attributes and exacerbating the effects of pollution. Agricultural programs have also encouraged the farming of land only marginally suited for crops.

Wetlands provide yet another contemporary example of mixed signals from policy makers. For decades, the federal government has provided assistance for draining moist soils for cropping. Since the mid-1980s, however, momentum has been growing — primarily in the non-farm sector — to protect and restore these habitats.

The federal government's abrupt turnaround on wetland issues has perplexed the agricultural community. At the same time, environmental groups view it as too little too late. The haunting question is, What would have happened if a sustained wetlands conservation effort had been integrated with farm policies and programs decades ago? Had this been the case, the overproduction of farm commodities would have been moderated, relatively pristine tracts of wetlands would have been preserved, and the farm community would have received a consistent message regarding the values of wetlands and the incentives to protect them — *before* it was too late.

Thus, public policy has helped shape farmers' long-term attitudes about land use and natural resources. Farmers have also had to consider their economic, if not personal, survival.

The neglect of ecological considerations has come at a tragic cost. But even the current era of environmental awareness and regulation will not necessarily produce more ecologically sound farming systems or develop a land ethic among those who fill America's bread basket. Environmental issues related to agriculture are a fairly new crisis to the public, and society at large has a short attention span for such crises.

The marriage of agriculture and ecology needs a long courtship. Is the public willing to make a sustained investment in research and education to make the marriage work? Aside from the threat of environmental regulation, does the agricultural sector have genuine interest in implementing ecologically appropriate farming systems?

As we ponder the future of agriculture, we should remember that Illinois is a bellwether for agricultural change. The farming concepts and practices that emerge from our ecological stress points may well determine the characteristics of many intensively farmed regions of the nation and the world.

Richard E. Warner, wildlife ecologist, Illinois Natural History Survey

Nursery Crops: A Growing Success

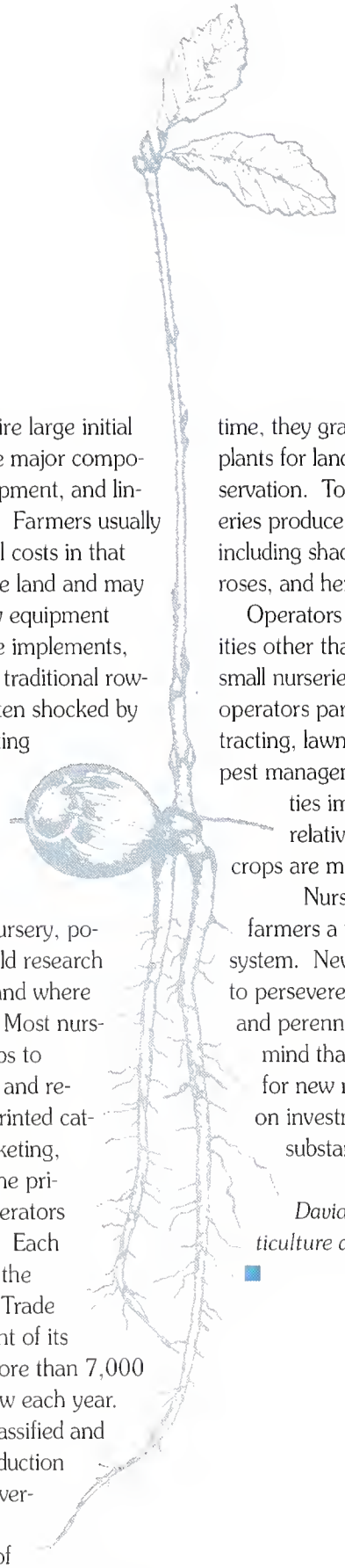
David Williams

The U.S. nursery industry blossomed during the 1980s. Since 1982, the greenhouse-nursery industry has grown at an average annual rate of 10 percent and in 1988 accounted for 9.6 percent of all farm-crop cash receipts. Aggregate greenhouse-nursery cash receipts for the United States totaled $6.9 billion in 1988, double the figure for 1980.

The demand for nursery crops continues to exceed the supply. Only in times of deep building recessions have decreases in the demand for these crops been felt. Nursery production in Illinois has expanded as long-time growers have increased their acreage and many new producers have entered the marketplace.

Illinois is an ideal state for nurseries in terms of both location and climate. Operators here have access to the urban markets of the Midwest and the East Coast. And, because it is geographically a long state, Illinois encompasses three U.S. Department of Agriculture hardiness zones. The average annual minimum temperature in these zones ranges from -20°F in the north (zone 5) to 0°F in the south (zone 7). This variety of climates enables growers to produce a multitude of crops — from dogwood and azaleas in the south to large shade trees and shrubs, the bread and butter of the north.

The high cash returns per acre have prompted many investors to inquire about growing nursery crops. Gross cash returns per acre commonly reach $50,000 to $60,000 for shade trees and $35,000 to $55,000 for shrubs. However, it is important to understand that the bottom line is profits, not gross income. Shrubs take from three to four years and trees four to seven years to reach harvestable size after planting.



Nursery crops require large initial start-up costs, with the major components being land, equipment, and linings-out stock (plants). Farmers usually have a leg up on initial costs in that they have access to the land and may already own necessary equipment such as tractors, tillage implements, and trucks. However, traditional row-crop producers are often shocked by the high costs of planting stock. Costs routinely run from $6,000 to $7,000 for trees and from $1,500 to $4,000 for shrubs.

Before starting a nursery, potential producers should research which crops to grow and where to sell their products. Most nurseries market their crops to landscape contractors and retail garden centers. Printed catalogs, direct-mail marketing, and trade shows are the primary tools nursery operators use to sell their crops. Each January, Illinois hosts the Mid-America Nursery Trade Show, the largest event of its kind in the nation. More than 7,000 people attend the show each year.

Nurseries can be classified and described by their production methods (that is, field versus container production), or by the types of plants they produce. In the past, nurseries typically produced fruit plants. Over time, they gradually began to include plants for landscaping, forestry, and conservation. Today most wholesale nurseries produce a variety of plant material, including shade trees, evergreens, shrubs, roses, and herbaceous perennials.

Operators often get involved in activities other than plant growing. Many small nurseries and new operators participate in landscape contracting, lawn care, tree pruning, and pest management. These diverse activities improve cash flow until the relatively slow-growing nursery crops are marketable.

Nursery crop production offers farmers a viable alternative cropping system. New producers should be able to persevere high initial investment costs and perennial crop cycles. But keep in mind that patience is truly a virtue for new nursery owners — the return on investment, though potentially substantial, will take time.

David Williams, professor of horticulture and Extension specialist

In Progress

Using Fly Ash to Study Soil Erosion

Soil researchers at the University of Illinois have uncovered a new method for determining levels of erosion caused by farming.

"For the first time, we can go into a basin and really identify the accumulation of sediments due to modern erosion," said Robert Jones of the Department of Agronomy. Jones developed the method with Kenneth Olson, a colleague in the department.

The technique involves testing soil for the presence of fly ash, small particles of residue from the burning of bituminous coal. Locomotives and steam-powered farm machinery used in the mid- to late 1800s were the first sources of fly ash in the Illinois soil surface. This time frame corresponds with the onset of widespread farming by settlers in the state. More recently, coal-fired power plants have added to the amount of fly ash in the environment.

Rain, the major cause of erosion in Illinois, washes unstable, intensively cultivated soils to sedimentation sites such as sideslopes and floodplains. Sedimentation sites thus contain more fly ash than do unstable soils.

Using the new technique, scientists can compare the amount of fly ash in stable, uncultivated sites with the amount found in nearby sedimentation sites. This information tells them how much sedimentation has occurred since settlers began farming the region about 130 years ago. This data also allows them to extrapolate rates of erosion.

"Geologic erosion and sedimentation was occurring long before European settlement of the area," Olson said. "What we needed was a way to separate geologic erosion from modern, or accelerated, erosion."

The U.S. Department of Agriculture has set standards for "tolerable" soil-loss rates. Losses of up to five tons per acre annually are considered acceptable. In some parts of Illinois, intensive farming contributes to more than twice that rate, Olson said.

The fly-ash method is quick, simple, and inexpensive. The techniques and instruments involved are only a soil suspension, a plastic-encased magnet, an eye-dropper, a microscope slide and coverglass, and a microscope. The spherical black, red, and yellow fly-ash particles are easy to distinguish and count under magnification. ■

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Illinois Research

Spring/Summer 1991

BIOTECHNOLOGY

Illinois Research

Agricultural Experiment Station
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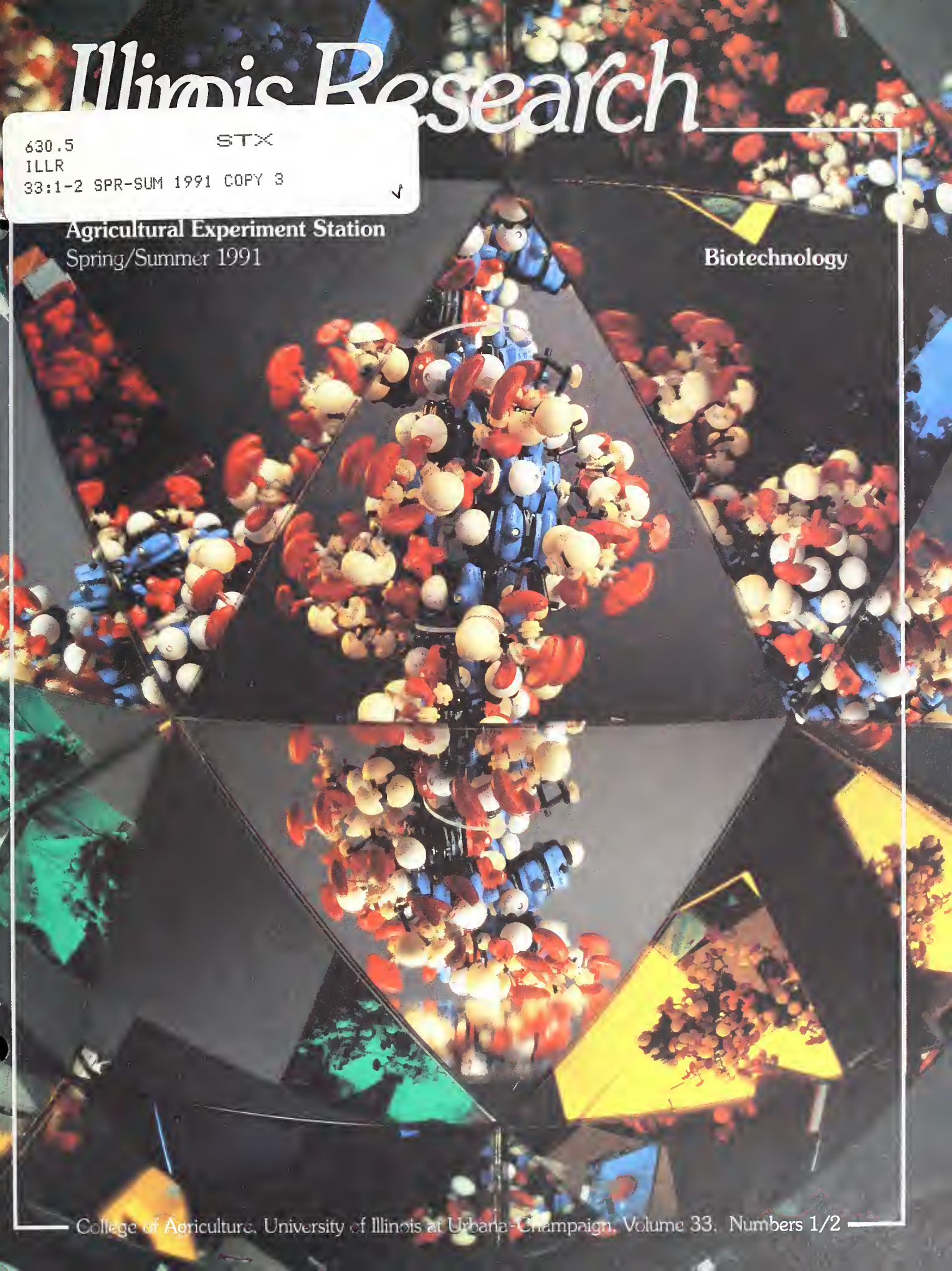
Biotechnology



College of Agriculture, University of Illinois at Urbana-Champaign, Volume 33, Numbers 1/2

The Cover

As the camera's lens fragments and reconstructs the image of the DNA model on the cover, the application of biotechnology offers the possibility of manipulating the real-world counterpart.

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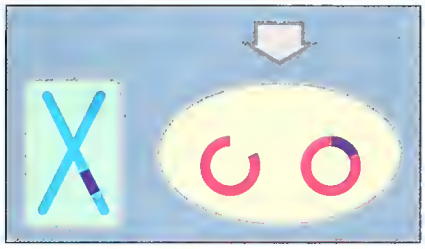
Raymond G. Cragele, AES Director, 1978-1983



1991 – Directions – 2001

Biotechnology: A Tool for Change

Throughout history, human beings have feared the wrath of the apocalyptic Four Horsemen: Famine, Pestilence, War, and Death. Those engaged in agriculture have always attempted to balance the years of plenty with those of famine — to grow enough to feed their people even after insects, animals, and bacteria had claimed their shares. The battle was always close-fought: the effort to avoid famine and death was successful only part of the time.

During the twentieth century, science and technology have permitted immeasurable gains in the battle for human survival. Food production at levels far beyond reasonable predictions has resulted from crossbreeding plants or animals for increased vigor and growth, the advent of artificial insemination, and other advances in plant and animal agriculture; losses to pests have been reduced to a fraction of former years; plant and animal diseases have been overcome or reduced; storage of food in a healthful state has improved remarkably; and the life-span of most human beings has been extended significantly.

These gains have not been without problems, however. We are now raising serious questions about the effects of pesticides, preservatives, and growth enhancers on the safety of our food, water, and environment. Issues of decreasing genetic diversity, global temperature changes, and preservation of natural habitats cause us to wonder whether we can provide nutrients for a growing world population while protecting the environment for future generations.

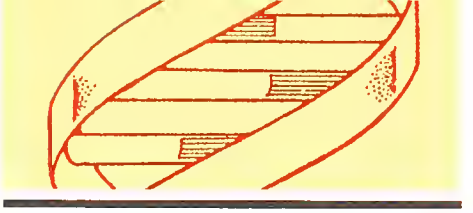
And the needs of the world's people will continue to grow. Today, nearly 5 billion people inhabit the earth. By the year 2030, that number is expected to double.

Recent issues of *Illinois Research* have addressed questions of conservation, sustainable agriculture, and quality of life. This issue is devoted to a new level of science, the molecular level, that could have sweeping effects. Plant and animal biotechnology promises newer, potentially safer solutions to continuing problems. New "biological controls" of diseases and pests could reduce our dependence on antibiotics and pesticides while enhancing our progress in health and conservation. The technologies described in this issue have the potential to increase our quality of life while alleviating or reversing many factors that may contribute to environmental problems.

In the final analysis, however, biotechnology is a tool, a powerful tool with remarkable potential for change. But with biotechnology also come the dilemmas that are always invoked by change. Will it be appropriately regulated? Will it be safe? Is it ethical? What will be its economic impact? Should we take the risks associated with new technologies or eschew their benefits to avoid the unknown? This issue of *Illinois Research* addresses those questions.

John Milton's 1667 classic, *Paradise Lost,* suggested that "fear of change perplexes monarchs." If we can overcome that fear and embrace change, biotechnology can be a useful tool.

W.R. Gomes, Dean of the University of Illinois College of Agriculture



Biotechnology: Issues, Ethics, and Regulations

Tina M. Prow

The public appears to lag behind in its understanding of technology in agriculture, and that concerns those who consider biotechnology to be a tool that could help solve problems ranging from environmental contamination to world hunger.

Issues

"In many ways, the public is still operating with the mentality of the 1970s," said George Kieffer, associate professor at the University of Illinois School of Life Sciences. "They're thinking in terms of creating monster organisms. But we've gotten experience on what can and cannot be done with biotechnology now; and, while those concerns are not to be dismissed as completely irrelevant, they are not the issues of the 1990s."

Public understanding of biotechnology as a science and technology is important because the products of biotechnology — and consequent benefits and risks — are going to affect everyone, Kieffer said.

"Some suggest a third agricultural revolution, in which we won't even grow plants — just cells in tissue culture rather than stems, roots, and leaves," Kieffer said. "That raises a social question about the effect on Third World economies that depend on agriculture."

The agricultural revolution is an extreme example, but represents how society must be involved in determining directions for biotechnology. "What are societal needs? What are the benefits? At what price? These are the kinds of questions we need to think about in the 1990s," he said.

Such questions may account for failure of the genetically engineered bovine somatotropin hormone to gain public acceptance, Kieffer said. It increased efficiency of milk production without improving milk's nutritional value. For consumers, he reasoned, the benefit did not offset their perceived risk from hormones on human health. After losing tomatoes to wilt yet again last year, however, he would find genetically engineered, wilt-resistant tomato plants acceptable.

"We have to ask what we are to gain from this — because there's no such thing as a completely benign engineered organism," Kieffer said.

Part of Kieffer's work is focused on making sure the next generation can understand biotechnology well enough to think through those questions. He helped develop a traveling kit for grades 7 through 12 and conducts workshops for teachers. The goal is to incorporate biotechnology topics into coursework.

Ethics

Scientists, too, are increasingly aware of their responsibility to help the public appreciate the role of science and technology in society, according to Robert Goodman. A former University of Illinois plant pathology professor, Goodman recently resigned from Calgene, Inc., a plant biotechnology company in California, to return to academia, as a professor at the University of Wisconsin–Madison.

Although it takes time and energy, scientists must talk about their work whenever they have an opportunity, Goodman said. He has spoken before legislators, explained proposed field research to communities, presented workshops, appeared on television programs, and been both author and subject of newspaper and magazine articles. He serves on the National Academy of Sciences Research Council's Board on Agriculture, which brings together panels of scientists to counsel government on science policy.

"For too long, we've had a very insular attitude in agriculture, and I think that's how we've come up with a public that has been deluded into thinking that our food supply is somehow pure and pastoral and basically free of technology, when in fact, it is very, very technology intensive," he said.

According to Goodman, biotechnology holds great promise as a tool to preserve and enhance environmental quality on and off farms. And years of plant breeding show that genetics is the most cost-effective, environmentally safe way to address problems that reduce yields.

But without public understanding, acceptance, and support, the role that biotechnology could play in solving environmental and food production problems could be stymied, he said.

"We've got a problem now with a society that doesn't completely understand agriculture; is deeply suspicious of biotechnology; and sees the same companies that sell what they consider nasty ag chemicals investing in biotechnology, or somehow controlling it," Goodman said. "At some level, that suspicious, cynical environment is actually reducing

the interest of the public in investing tax dollars in research."

Annually, the public invests $110 million in agricultural biotechnology through the U.S. Department of Agriculture (USDA). At just 10 percent of the total USDA research budget, that is not enough, according to Alvin Young, director of the USDA Office of Agricultural Biotechnology, Washington, D.C.

Regulation

Young said most university scientists conducting biotechnology research receive federal money. And all scientists deal with the government before research moves from the laboratory to the field. At that stage, they go before regulatory agencies to prove their research is safe.

"We probably, for this new technology, have put more effort into putting in place a regulatory oversight mechanism than we have for any technology in the past," he said.

Young said there is no evidence that biotechnology poses additional risk, but there are uncertainties that concern the public. He pointed to public attitude as a reason for a regulatory system that critics say stifles research. But while biotechnology companies are asking for a more streamlined regulatory system, they are proceeding with field tests. Universities, however, had few of the permits for field testing that were issued in 1989.

The regulatory program may account for some of the lag in field testing, but it is just as likely due to a "funding crisis" in research, Young said. The research community may soon feel even more of a pinch as fewer students choose to become scientists, in part because of funding problems. The end result may be a significant slowdown in what he described as the biotechnology "pipeline."

"You're constantly putting in new ideas coming out of research; those new ideas work their way through; they're evaluated; they turn into products," Young said. He suggested that plant-related biotechnology research is progressing rapidly, and some potential products are in the pipeline. Animal-related biotechnology research, however, has proved to be more complex than scientists anticipated, both in terms of genetics and social issues.

"Most people haven't worried much about transferring genes from one plant to another or transferring a gene from a microorganism into a plant; most people don't care. But when you talk about transferring human genes into fish, for example, some people begin to picture mermaids," Young said.

For scientists, however, the process is one of taking a gene, examining it, and building its synthetic model. Where the public sees human genes and fish genes, scientists see a "commonality" in life that holds potential for such uses as curing or preventing diseases.

"Critics can spend much effort and resources on misinformation, and never be held accountable," Young said. "Public perception is something we have to deal with better. We must try to involve the public in our decision making and public hearings and invite them to see the kind of research we're doing."

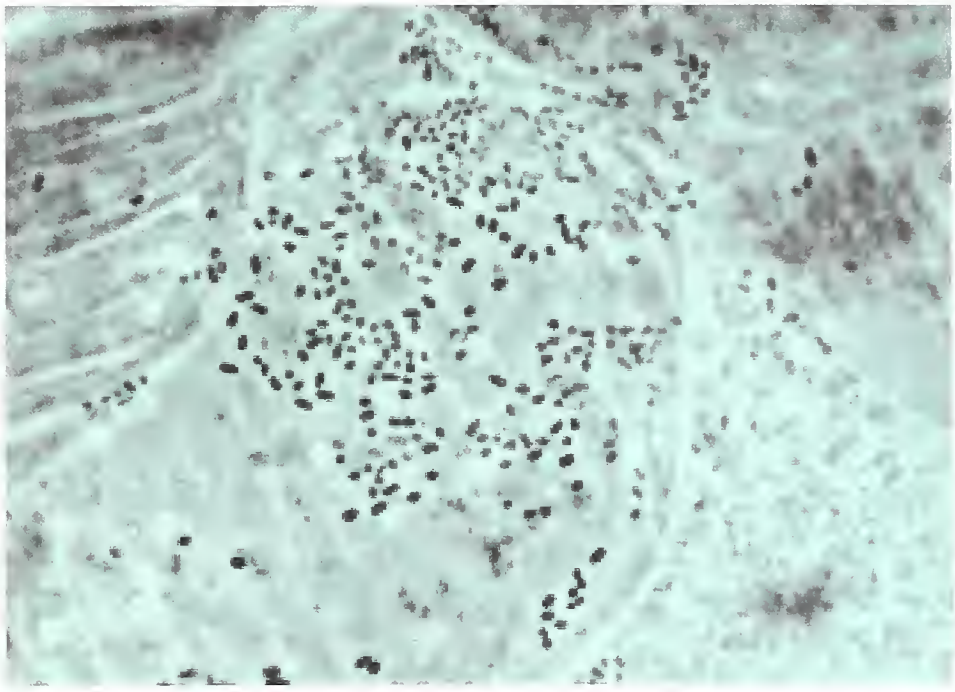
That will happen more often this decade as research is completed for several promising products — disease-, insect-, or herbicide-resistant plants; leaner meats; and more nutritious crops — in the pipeline, he predicted, saying that consumer education will be a critical part of successful commercialization.

With an educated, 1990s viewpoint, then, consumers may see a genetically engineered, wilt-resistant tomato plant as Kieffer does — not as the coming of the killer tomatoes, but as opportunity to grow juicy, flavorful tomatoes.

Tina M. Prow, communications specialist, Office of Agricultural Communications and Education

The Role of Plants in Environmental Toxicology

Michael J. Plewa



Interaction between Salmonella typhimurium *and tobacco cells. The plant cell is the large kidney-shaped object; the bacteria, the darkly staining small rods. It is the bacteria that are studied for DNA damage after a promutagen has been activated by the plant cells.*

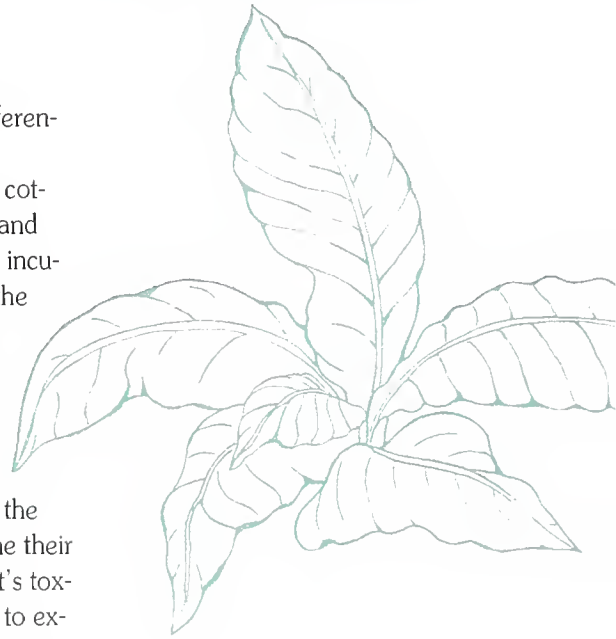
Most of us are concerned about the poisoning of our planet. But even well-informed people may be unaware that plants accumulate, metabolize, and distribute environmental contaminants.

Plants can become a reservoir for these contaminants. Because plants are exposed to environmental pollutants, agricultural chemicals, and naturally occurring toxic agents, plant-activated agents may be introduced into the human food chain. Thus, effects of environmental toxins on plants have a global impact.

Our research uses cultured plant cells to identify promutagens and the biochemical pathways involved in their metabolism. Although promutagens do not damage DNA (the genetic material), they can be biologically transformed into mutagens, agents that produce mutant forms of plants or animals.

Plant and mammalian metabolic systems activate many promutagens. But several environmentally important agents — several s-triazine and thiocarbamate herbicides and plant-growth regulators such as maleic hydrazide — are preferentially activated by plant cells.

The plant cells (cultured tobacco, cotton, carrot, or maize *Tradescantia*) and microbes (bacteria or yeast cells) are incubated together. The plant cells are the activation system and the microbes are the genetic indicator organisms. After the microbes are spread on a selective medium, only mutant cells grow into individual colonies.



Researchers independently study the plant cells and microbes to determine their viability and evaluate each test agent's toxicity. Basic research uses this assay to explain the biochemical mechanisms of plant activation and to analyze plant-mediated antimutagens. Such research could potentially identify chemicals that reduce the toxicity of environmental contaminants.

Michael J. Plewa, professor of genetics, Institute for Environmental Studies, departments of Agronomy and Microbiology

Improving Nutritional Quality of Meat Animals

Floyd K. McKeith

Lean tissue quantity and quality are the major factors in determining the value of meat animals. A continuing goal of the livestock industry is to increase the quantity of high-quality lean tissue; and scientists have used technologies based on genetics, nutrition, and physiology to achieve this goal. Increased consumer demand for lean meat has stimulated the need for technologies to reduce fat and increase lean in meat animals.

Repartitioning agents (beta-adrenergic agonists and somatotropins) are compounds that increase lean content and reduce fat content of meat animals, while improving the rate and efficiency of growth. Although studies on cattle and sheep have also been conducted, the bulk of information available about repartitioning agents involves pigs. Current studies at the University of Illinois and elsewhere are evaluating the potential of these products for the beef industry.

Somatotropins. Somatotropin is a protein normally found in all animals. By augmenting existing somatotropin levels with exogenous somatotropin, swine producers can alter the composition of the meat animal. Studies conducted at the University of Illinois indicate that the fat content of meat animals may be reduced by 25 percent using only 3 milligrams of somatotropin per day. Fat reduction improves nutritional quality of meat animals by reducing fat between muscles, thus improving the yield of consumable lean, and thereby enhancing how consumers view meat products. Results from our studies indicate use of somatotropin causes only small changes in pork's tenderness, juiciness, and flavor. Improvements in meat animal composition were accompanied by increased average daily gain (10 to 20 percent) and increased feed efficiency (10 to 15 percent). Increased availability of somatotropin for research and Food and Drug Administration (FDA) evaluation is due to recent advances in biotechnology.

Beta-adrenergic agonists. These feed additive products result in improvements in meat animal composition and the rate and efficiency of growth. Several different compounds have been developed and evaluated. After evaluating cimaterol and ractopamine in our laboratories, we found that these two beta-adrenergic agonists reduced meat animal fat by 10 to 15 percent, while improving average daily gain and feed efficiency by 10 to 15 percent. No consistent differences in color, firmness, or marbling were observed in the quality of the lean meat produced from these animals.

Although somatotropins and beta-adrenergic agonists are unavailable on the marketplace today, the FDA is evaluating their safety and efficacy for future use in the livestock industry.

Floyd K. McKeith, associate professor of animal sciences

Effects of porcine somatotropin (pst) on American and Chinese pigs at the same age.

Links to Industry

Tina M. Prow

Last year, the University of Illinois released high-oil corn germplasm to industry in a move to further research and bring a potentially high-value crop to farmers.

Du Pont Company and Pfister Hybrid Corn Company gained an exclusive license to develop and commercialize germplasm. They agreed to pay royalties to the University and to fund a collaborative research program that brings together Du Pont and University of Illinois researchers.

The agreement represents the kind of relationship between industry and universities necessary to sustain and renew agriculture, according to John Goss, research supervisor in Du Pont's Stine-Haskell Research Laboratory, Newark, Delaware.

"We're not just an additional funding source," Goss said. "I see our collaboration as part of the Agricultural Experiment Station's effort to do a better job of getting the technology and new products out into the agricultural community.

"And we see having more collaborative relationships with the University as a way we can access other technologies for a fair royalty and research funding commitment, thus allowing us to more rapidly determine whether or not a business opportunity exists and, if it does, to get it to the marketplace."

Traditionally, industry has looked to university researchers for long-term research, cutting-edge discoveries, and new technologies, said Robert Fraley, director of Monsanto's Plant Science and Technology Program, St. Louis. In the biotechnology arena, however, many companies have internal research capabilities and programs of their own.

Still, the field is moving so quickly that every research program is dependent on discoveries made in other laboratories, Fraley said. Consequently, collaboration is key to keeping abreast of important developments, maximizing resources, and minimizing risk.

"We're looking for the type of interaction that involves the true exchange between scientists at a university and at Monsanto; where we can bring different pools of expertise together, or different ways of attacking a complicated problem," he said. Monsanto, with an eye toward recruitment and a predicted shortage of scientists, also provides funding for University of Illinois science students and hosts tours to familiarize young scientists with industry research.

A collaborative relationship will be even more important as biotechnology-based products begin to move from laboratories to field research, through the regulatory process, and then to consumers. Gaining regulatory approval and public acceptance of such products will be a challenge for the entire research community, he said.

"Almost everything I see — whether driven by pure research interest, limited funding that's available, or the magnitude of the commercialization issue — forces a tight linkage in partnership to ensure that we have the best possible chance for success," Fraley said.

Both Goss and Fraley are University of Illinois graduates. Tina M. Prow, communications specialist, Office of Agricultural Communications and Education

Agronomy students were invited for Science Daze at Monsanto last summer.

The Economics of Biotechnology in Field-Crop Production

Lowell D. Hill and Wojciech J. Florkowski

U.S. scientific leaders in the development of agricultural biotechnology can contribute to the economic growth of many countries by commercializing plant cultivars that possess improved genetic characteristics. The potential for increased production and decreased costs has been emphasized by most researchers. But limited resources, the high cost of research, and the undesirable effects of past adoptions of technology have made the public and research community more aware of the importance of evaluating other economic impacts before adopting the new biotechnologies. Additional information is needed about the price and income effects of the increased production and about who gains and who loses market share, income, and welfare — the distributional effects of economic change.

The U.S. Department of Agriculture (USDA) and the Office of Technology Assessment of the U.S. Congress have studied the impacts of agricultural biotechnology and other modern technologies. But most of the studies have avoided the issues of the changes in income and welfare among firms, regions, and economic sectors as the technologies have been commercially adopted.

Policy analysts of economic and social consequences have often relied on qualitative evaluation without quantifying the results. Useful insights into relationships among the important variables can be obtained by quantifying at least those consequences that emanate from direct changes in the quantities produced. Subsequent changes will cause additional adjustments in quantities, and the ripple effects quickly go beyond the capacity of simplifying mathematical models.

The Study

A study was carried out to provide estimates of the welfare changes associated with commercialization of alternative plant biotechnologies. Twelve specific plant technologies were selected for the study: symbiotic changes, new rhizobia strains, altered protein content, virus-resistant varieties, bacteria-resistant varieties, fungus-resistant varieties, insect-resistant varieties, frost-tolerant varieties,

The Kunitz Soybean Variety

Theodore Hymowitz

In 1917, T.B. Osborne and L.B. Mendel, researchers at the Connecticut Agricultural Experiment Station, demonstrated that unheated, raw soybean meal is inferior in nutritional quality to steam-heated soybean meal. Their research became the foundation for the development of the lucrative soybean processing industry and expanded the potential use of soybean meal as a high-protein feed. Physiologically, the ingestion of raw soybean meal by monogastric animals (for example, poultry or swine) causes pancreatic hypertrophy, a condition in which the pancreas enlarges and ultimately ceases to function.

Moses Kunitz, professor of biochemistry at New York's Rockefeller University, purified and characterized the predominant antinutritional factor in soybean seed in 1945. This factor, a trypsin inhibitor, bears his name and is inactivated during moist heat processing.

In 1968, the author and his colleagues at the Illinois Agricultural Experiment Station began to study the variations in and the genetics of the Kunitz trypsin inhibitor in soybean seed. Thousands of seed samples from the USDA soybean germplasm collection in Urbana, Illinois, and Stoneville, Mississippi, were screened for variation in the Kunitz trypsin inhibitor. Four different trypsin inhibitor (*Ti*) forms were discovered. Three of the forms identified as Ti^a, Ti^b, and Ti^c are distinguishable from one another by banding patterns produced on gels. The differences are due to amino acid substitutions in the protein. Genetic studies have revealed that the three forms are controlled by a co-dominant multiple allelic system at a single locus. All major soybean varieties grown in the United States contain the Ti^a form.

The fourth form, found in soybean germplasm samples PI 157440 and PI

herbicide-tolerant varieties, heat-tolerant varieties, plant growth regulators (PGRs), and ice-retarding bacteria. The principal criterion for selection was the probability of rapid commercial adoption.

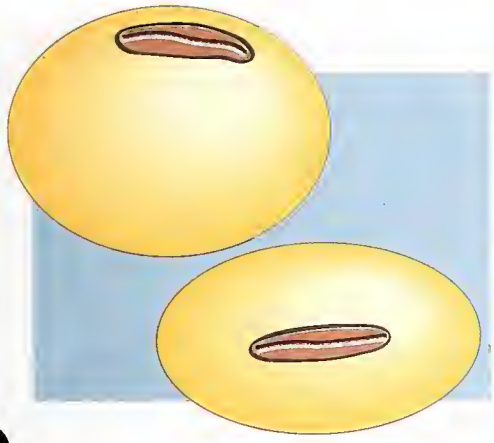
The effects of these alternative biotechnologies on major crops were measured for ten regions of the country, covering both nonirrigated and irrigated land. The model used published statistics on the cost and quantities of inputs applied per acre for nine row crops: barley, corn, cotton, oats, peanuts, rice, wheat, sorghum, and soybeans.

Welfare is measured by consumer and producer surpluses. The analysis gives information about the potential regional reallocation of agricultural land to alternative uses and about welfare gains to consumers. The models used in the analysis demonstrate long-term, aggregate effects of each new technology, assuming full adoption. Impacts of each technology were examined independently of the other eleven; no simultaneous adoption of two or more technologies was allowed in the model.

Model Solutions

Model solutions show a decrease in total acreage used for the production of the nine crops included in the analysis after the introduction of biotechnology. Irrigated and nonirrigated land withdrawn from production is located in the Delta and Southeast and, to a smaller extent, in the Appalachian, Mountain, and Northern Plains regions. The affected regions represent a range of different climates and growing conditions that offers a potential for developing specialized agricultural production.

The decrease in acres planted to row crops resulting from yield-increasing technology will slow the degradation of the environment. Replanting the withdrawn land with perennial or cover crops would lower soil erosion. The technologies that would cause the largest relocations of crops and prove beneficial from the standpoint of soil protection are the use of PGRs, heat-tolerant cultivars, bacteria- and virus-resistant plants, and cultivars with altered protein content.



196168, lacks the Kunitz trypsin inhibitor. The absence of the protein is inherited as a recessive allele to Ti^a, Ti^b, and Ti^c, and has been designated *ti*. Although other inhibitors may be present in the seed of PI 157440 and PI 196168, all experimental evidence from genetic, biochemical, and molecular studies indicates that the seeds of the two accessions lack the Kunitz trypsin inhibitor.

The Kunitz soybean variety was developed by backcrossing and is the progeny of an F_2 plant selected from the fifth backcross, Williams 82(6) × PI 157440. Kunitz is similar to Williams 82 in all visible traits such as white flowers; tawny hairs; tan pods; and shiny, yellow seeds. Kunitz is resistant to many races of phytophthora rot, bacterial pustule, leaf spot, and powdery mildew. Kunitz is also similar to Williams 82 in yield performance, and in the seed's protein and oil content.

The advantages of the Kunitz soybean variety over other commercial varieties are as follows:

- Farm-grown soybeans can be fed directly to swine in their finishing rations.
- Kunitz can replace as much as 50 percent of the heated soybean meal in chick rations.
- Processors can save about 25 percent in energy costs in processing Kunitz soybeans.
- Kunitz can be exported to those countries lacking soybean processing facilities.
- Kunitz is an excellent raw product for companies making soy-based foods for babies.

Theodore Hymowitz, professor of plant genetics, Department of Agronomy

The four technologies most beneficial to society, as measured by the change in total surplus (consumer plus producer returns), are cultivars with altered protein content, virus- and bacteria-resistant cultivars, and cultivars responding to PGRs. This ranking was largely influenced by the size of consumer surplus, which was the highest for these technologies. All biotechnologies negatively affected producer surplus — the smallest effect being that from commercialization of cultivars with altered protein content, and the largest being the effect of widespread use of PGRs. Assuming no change in demand, a larger volume of commodities causes lower gross income in the aggregate as a result of a percentage decrease in prices that is greater than the percentage increase in output. In the cost data used in this model, the new technologies did not sufficiently reduce the cost of production to compensate for lower prices.

Thus, the introduction of new technologies decreases aggregate farm income, as measured by producer surplus. Realized income on an individual farm may decrease or increase, depending on market price, skillful application of the new technologies, and benefits of early adoption. The reduction in farm income shown by the models is the direct result of increased supply under the assumed price elasticities. The negative effects on the producer sector can be alleviated by expanding demand, finding new uses, and controlling supply through government action; by transferring income from consumers, processors, and other groups that benefit from lower crop prices; and by lowering production costs.

Aggregate income of the agricultural sector in each region will be affected differently as a result of differences in crop rotations, importance of certain crops in a region, and the different yields and costs of production in each region. For example, a larger portion of total farm income will go to producers in the Midwest who have a comparative advantage in production of row crops.

Conclusion

The impact of biotechnology illustrates a polar case of a long-term full adoption of twelve separate technologies applied to a limited number of field crops. The information about potential future land allocation and welfare changes contributes to the constantly expanding pool of knowledge concerning predictions of the impact of agricultural technology.

Specifically, this study indicated to agricultural research administrators the perceived probabilities of developing different biotechnologies and economic impact of their commercialization. Allocation of research funds may be determined not only by the short-term success in developing a technology but also by its long-term welfare effects. Welfare effects, in turn, may not be limited to the easily quantifiable changes in total surplus. These may also include the effect on quality and sustainability of natural resources, such as unpolluted water or uneroded soil. Some of the biotechnologies considered in this study would lower pesticide use and withdraw land from agricultural production.

Policymakers may use the information from this study to formulate policy goals that would make the necessary adjustments easier and to fully explore benefits offered by the use of biotechnology in crop production. For example, programs for alternative land use or economic programs that sustain rural community growth may be needed as agriculture diminishes in importance.

For farmers and farm groups contributing funds for research and market development, the results of this study suggest paying more attention to the demand for agricultural crops. Traditional food, feed, and fiber use of grains, oil crops, and cotton could be augmented by industrial uses of crops. Industrial use of agricultural crops would change the demand structure and create new markets. Research funds applied toward research on new uses of commodities and on feasibility studies of new markets could make biotechnology work to the benefit of farmers.

This article is excerpted from a recent Station bulletin, Economic Impacts of Commercial Applications of Biotechnology in Field Crop Production. *Bulletin 799 is available for $3 from the Office of Agricultural Communications and Education, (217)333-2007.*

Lowell D. Hill, L.J. Norton Professor of Agricultural Marketing, Department of Agricultural Economics, and Wojciech J. Florkowski, assistant professor of agricultural economics, University of Georgia and Georgia Experiment Station, Griffith, Georgia

Biotechnology of Grain Quality Traits

Alan L. Kriz

Alan Kriz examines laboratory corn plants.

The value of grain crops accrues from the types of compounds that normally accumulate during the important stage of seed development commonly referred to as grain-filling. During this period, compounds such as protein, starch, and oil accumulate to high levels as part of the natural seed growth process. Over the past century, plant breeders have developed new varieties of seed crop plants that allow for increased production of grain components. Advances have been made not only with respect to increasing the starch, oil, and protein content in the seed but, in some cases, to the quality of these components as well. For example, naturally occurring genetic variation has allowed maize varieties to develop with modified starch content and increased or altered oil content.

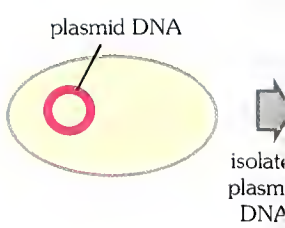
An important aspect of grain quality that is being studied at the University of Illinois Department of Agronomy involves the nutritional characteristics of seed proteins. Seed proteins of any given crop usually do not contain sufficient quantities of certain amino acids that are essential in the diet of humans and other monogastric animals. Because cereals are usually deficient in lysine and tryptophan, and legumes are deficient in the sulfur amino acids methionine and cystine, a mixture of cereals and legumes is used to provide a balance of amino acids in the diet.

Nutritionists have specified those aspects of grain protein quality that are most desirable, but to date the development of corn or soybeans containing a satisfactory balance of amino acids has not been possible. Plant breeders have had only limited success in improving the nutritional quality of seed proteins, primarily because genes encoding the seed storage proteins with high levels of essential amino acids do not normally exist in any given species. Modifying the genes that encode seed proteins by genetic engineering may therefore be an ideal solution to the problem of nutritional quality.

A general approach to enhancing grain nutritional quality involves altering the proteins in the grain that normally contain the bulk of the amino acids. Specific genes from plants are readily isolated. Using routine laboratory techniques, the DNA sequence, or program, of those genes is then altered to create a new gene sequence that encodes a protein of desirable nutritional quality. For example, over a few months, we have been able to increase the lysine content of a specific corn grain protein by 50 percent, and the tryptophan content of that same protein by 700 percent. The extent to which the seed tolerates such altered genes remains to be seen.

However straightforward the genetic engineering approach, certain problems must be overcome to apply successfully this technology to the particular problem of improving seed protein quality. Recombinant DNA clones are routinely isolated that correspond to genes that encode specific proteins. These clones may be easily manipulated so that they contain appropriate instructions for desired amino acids. The major limitation in implementing this technology now is the lack of efficient genetic transformation systems for corn and soybeans. But recent advances in this area indicate that it will soon be possible to use biotechnology to genetically manipulate grain protein quality in these major crop species.

Alan L. Kriz, assistant professor of crop molecular genetics, Department of Agronomy



Microbial Biotechnology

Hans-Peter M. Blaschek, Roderick I. Mackie, and Paul D. Shaw

Microorganisms have been exploited for their specific biochemical and physiological properties from the earliest times for baking, brewing, and food preservation and more recently for producing antibiotics, solvents, amino acids, feed supplements, and chemical feedstuffs. Over time, there has been continuous selection by scientists of special strains of microorganisms, based on their efficiency to perform a desired function. Progress, however, has been slow, often difficult to explain, and hard to repeat.

Recent developments in molecular biology and genetic engineering could provide novel solutions to long-standing problems. Over the past decade, scientists have developed the techniques to move a gene from one organism to another, based on discoveries of how cells store, duplicate, and transfer genetic information.

Recombinant DNA technology has vast potential benefits, and agriculture is a prime area where these modern techniques will have greatest impact. Recombinant DNA techniques may provide us with disease-resistant crops, feed crops with higher nutritional and digestive quality, improved vaccines for animal health, hormones to enhance milk and meat production, enzymes to improve digestion of feedstuffs, new ways to clean up our environment, and more efficient methods to produce chemicals.

Fermentation Biotechnology

Until recently, fermentation processes depended on a few types of raw materials (substrates) and on available strains of microorganisms. But now microbes can be genetically manipulated to function more efficiently and to use a wide variety of substrates. As these microbes are re-engineered and their fermentation capabilities fully exploited, we rapidly near the day when chemicals can be produced economically and naturally.

The development of any successful industrial process ultimately depends on efficiently converting the substrate to a highly concentrated end product. Because of the potential for commercial success, research in the Department of Food Science is focused on the acetone-butanol-ethanol (ABE) fermentation. To make the ABE fermentation economically viable, several problems must be addressed.

The first problem relates to how product toxicity leads to low concentrations of butanol in the fermentation broth. The microorganism *Clostridium acetobutylicum* is intolerant of low concentrations of butanol; as little as 1.3 percent inhibits growth and fermentation. Increasing the butanol from 1.3 to 2 percent in the fermentation broth decreases the energy required for product recovery by 50 percent.

Another problem is the limited spectrum of substrates that can be used by the microorganism.

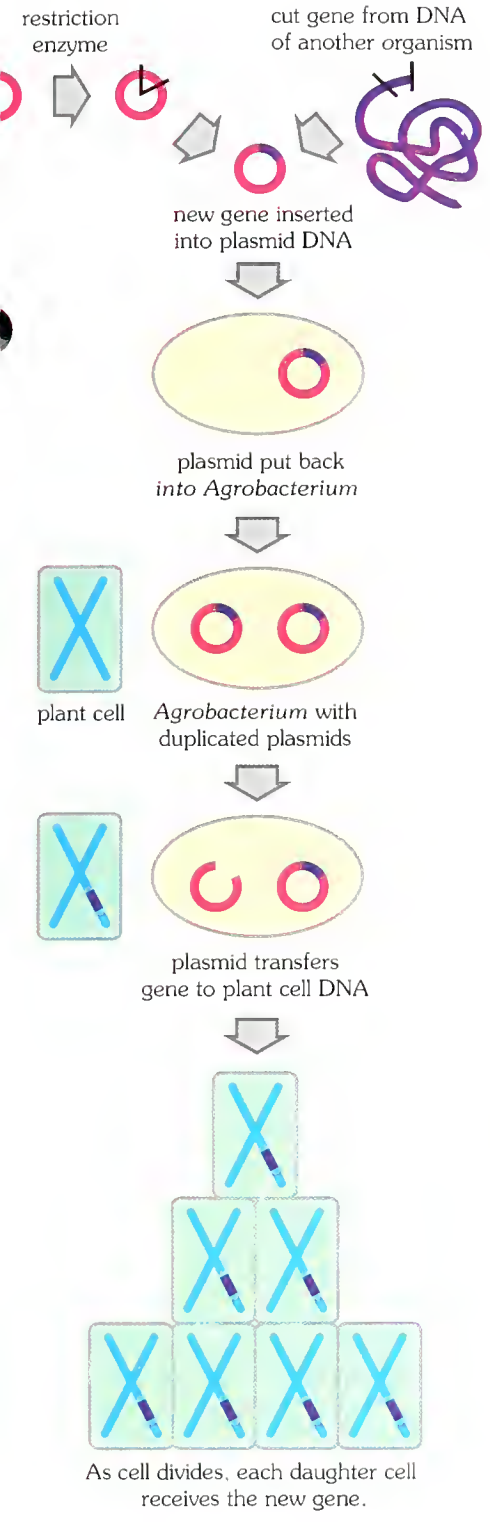
Work in Hans Blaschek's laboratory develops tailor-made strains of *C. acetobutylicum*, a microorganism that tolerates butanol and uses starch or cellulose to produce butanol. The approach involves cloning genes capable of hydrolyzing cellulose (called cellulases), and starch (amylases) into *C. acetobutylicum*. Although the application of genetic engineering techniques to *C. acetobutylicum* is still in its infancy, the potential for improving the fermentation characteristics of this microorganism is great. This technology should allow for improvements in the sequence of enzyme-catalyzed reactions, end-product tolerance, and the actual enzyme systems of this microorganism.

Potential benefits to the food industry include a practical and economical means to dispose of agricultural wastes and processing by-products. Furthermore, biomass-derived chemicals should help reduce our dependence on fossil fuels, the current source of these chemicals.

Rumen Microbiology

Ruminant animals (cattle, sheep, goats, and many other animal species) are nutritionally dependent on the activity of microorganisms present in the rumen. This dependence is based on microbial activity that degrades plant fiber, uses nonprotein nitrogen (NPN), and transforms phytotoxins or toxins produced by plants.

The approach being taken in the Department of Animal Sciences by Bryan White is to improve ruminal fiber digestion by amplifying the cellulose-hydrolyzing capabilities of predominant cellulolytic bacteria in the rumen, the Ruminococci. The complex cellulase enzyme system of *Ruminococcus flavefaciens* FD-1 has been studied extensively. Three synergistic cellulase components (exo- and endo-



Source: Adapted from *Introduction to Plant Biotechnology*, K. McPheeters, Vocational Agriculture Service (1989).

glucanases) have been purified to homogeneity, characterized biochemically, and used to elicit specific antibodies for immunological studies on enzyme location and function. These results suggest that the β-glucanases of the Ruminococci have more bond specificity than sugar specificity and probably play an important role in cell wall hydrolysis, a chemical process of decomposition.

Molecular cloning experiments of cellulases from *Ruminococcus flavefaciens* FD-1 have identified at least four different genes encoding for endoglucanase activity. DNA sequence analysis in progress will provide vital information on the regulatory and mechanistic elements of cellulose hydrolysis by these rumen bacteria.

Thus far, gene transfer systems have not been established in ruminal bacteria. One of the barriers is the presence of restriction-modification systems that cause extensive cutting of introduced DNA. Several restriction-modification systems have been identified in the Ruminococci and our understanding of their activity will potentially result in successful DNA transfer and allow the reintroduction of cloned (modified) genes back into the original host. Both the potential benefits and the problems involved in this research are great. Before this technology becomes a reality and genetically engineered organisms can be reintroduced into the rumen to enhance plant fiber degradation, however, a sustained and substantial commitment will be required.

Plant Pathogens

The roots and aboveground parts of a plant growing in soil are in constant contact with thousands of different microorganisms, most of which do not affect the plant in any easily observable way. Although bacteria capable of invading plant tissue and causing disease are rare, many of them are closely related to the harmless bacteria also found in soil and on plant surfaces. The plant pathogens, disease-causing agents or organisms, thus have unique properties that could be useful in devising ways to control the diseases they cause.

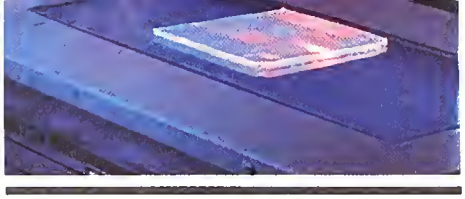
One species of bacteria being studied in Paul Shaw's laboratory is *Pseudomonas syringae* pathovar *tabaci*, one of about 50 different pathovars of that bacterium that cause diseases on many plants from apples to zinnias. The strain under study infects green beans and tobacco, causing a disease called "wildfire," due to the rapidity with which it can spread in a field.

A second species of bacteria is *Xanthomonas campestris* pathovar *glycines*. *X. campestris* also causes disease on many plants, but pathovar *glycines* attacks only soybeans and causes bacterial pustule, in terms of yield loss, one of the most serious bacterial diseases of soybeans in Illinois.

The initial objective of the research was to identify genes responsible for making the bacteria plant pathogens. The techniques of molecular biology are used to isolate pathogenicity genes from the bacterial chromosome. Although eight such genes have been found in *P. syringae* and more than 16 in *X. campestris*, it is not likely that they represent all the pathogenicity genes present in the bacteria. Many genes are translated into proteins or molecules responsible for carrying out most cellular functions. The next step, therefore, was to determine if the isolated genes had the potential to encode proteins. The four genes examined thus far appear to have that capability, and one likely candidate for a pathogenicity protein has been detected.

The ultimate objectives of the research are to determine the functions of the proteins and to define their roles in pathogenesis or disease origin. For example, one of the potential proteins from *X. campestris* is probably present in the membrane that surrounds the bacterium and might therefore be involved in transporting nutrients or other compounds into or from the bacterial cells from culture media, intercellular plant fluids, water on the plant surface, the aqueous milieu in the soil or wherever the organism is growing. Other pathogenicity proteins will be characterized so that they can become targets for disease control measures.

Hans-Peter M. Blaschek, professor of food science; Roderick I. Mackie, visiting professor of animal sciences; and Paul D. Shaw, professor of biochemistry, Department of Plant Pathology



Animal and Plant Genomic Research

Lawrence B. Schook and A. Lane Rayburn

The current emphasis of biotechnology in animal and plant agriculture is the need to identify and manipulate genes affecting disease resistance, growth, and other economically important traits (for example, seed-oil content or fat content of meat or milk). By constructing "genetic road maps" for major livestock and food crops, researchers can assist producers in providing improved and safer food for world markets. Genomic research also provides tools for applying this information through improved breeding programs, direct manipulation of genes through growth promotants, and — through genetic transformation — the ability to create unique new animals and plants resistant to diseases and adaptable to variable climate conditions.

Approaches and Tools

Research initiatives in both animal and plant genomic research have provided new methods and tools for using standard principles of breeding and selection. Domestication of animals and the development of hybrid crops have served us well. Our understanding of the organization of animal and plant genomes (genetic composition) has increased greatly in recent years. Our interest in learning about the human genome has provided a strong scientific base for agricultural efforts.

Several approaches are used to map, identify, and characterize genes. Linkage mapping uses crosses to locate genes relative to others in progeny. Restriction fragment length polymorphisms (RFLPs) play an integral role in creating genetic linkage maps (see related sidebars by Dudley and Rocheford). In RFLP maps, special enzymes are used to cut the deoxyribonucleic acid (DNA) of an organism into smaller pieces. The patterns revealed by probing the cut DNA provide information that can be used to determine linkage of traits to specific RFLP patterns. Establishing such linkages allows both animal and plant researchers to more efficiently develop organisms of increased agricultural performance.

Another method to identify and characterize genes is to physically identify their location on chromosomes and to clone genes using recombinant DNA technologies. The use of recombinant DNA techniques is extremely important in constructing novel genes to enhance and control the proteins encoded by them, which affect production traits.

Benefits to Producers and Consumers

Lawrence Schook and Harris Lewin, Department of Animal Sciences, organized a USDA-supported international conference, "Mapping Domestic Animal Genomes: Needs and Opportunities," during April 1990. Participants represented international industry, governments, universities, and research institutions. A major recommendation was to develop genetic linkage maps for the agriculturally important animal species, maps to explore and use the genes for disease resistance, reproduction, and growth traits.

Currently, the Department of Animal Sciences has several research projects funded by the USDA, the National Pork Producers Council, and various international agencies. Lewin is developing strategies and techniques (RFLPs of individual sperm) to detect major genes affecting growth, lactation, and development in cattle. His group is one of the first to demonstrate how genomic markers can be used to select animals for faster growth and meat properties.

James Robinson and Roger Shanks are using new molecular approaches to identify dairy cattle that carry a recessive gene responsible for embryonic death. Scientists collaborating in the colleges of Agriculture and Veterinary Medicine focus on providing safer food by understanding the genetic basis of salmonella food poisoning and how the bovine leukemia virus affects milk production.

The recently imported Chinese pigs have stimulated new research activities. For example, a multidisciplinary team (Schook, Lewin, David McLaren, and Matthew Wheeler) has initiated a long-term program to determine the genetic basis for carcass composition and reproductive prolificacy in swine.

An international program headed by David Thomas is using genomic research methodologies aimed at improving the prolificacy of sheep.

University of Illinois researchers are also providing leadership in developing new techniques that unravel the mysteries of inheritance. Rohan Fernando has developed statistical models for using

Graduate student Suzanne Boussard prepares a DNA sample for electrophoresis. Electrophoresis is the movement of molecules through a fluid or gel under the action of an electric current.

genetic markers to assist in animal selection to increase rates of genetic improvement. Lewin, Wheeler, Carol Whetstone, Marite Ivanova, and Schook are developing strategies to manipulate genetically and select embryos that will result in cattle and pigs with enhanced growth, meat quality, and disease resistance.

In the last decade, major advances in molecular biology have permitted the incorporation of novel genetic material into plant species. Cultivated plant species will realize the promise of this technology through the addition of genes that will result in the decreased use of pesticides, increased pest resistance and nutritional value, enhanced adaptation to environmental stress, and alternative uses for the plants.

Dudley and Rocheford have used genetic road maps to identify genes controlling quantitative traits of economic importance in corn. In crops such as soybeans where molecular maps are not yet fully developed, Ted Hymowitz and Lila Vodkin are providing valuable information for developing these maps.

Genome mapping studies, while important to genetic manipulation, are not the only ongoing genomic research at the University of Illinois. Researchers are working to improve transformation and regeneration of specific crop species (Jack Widholm), to identify and manipulate genes to target for transformation (Alan Kriz), and to optimize the expression of genes introduced into plant species in both the amount of product and which tissues are producing the

product during plant development (Steven Farrand and Angus Hepburn).

Critical to the manipulation of crop plants is increased understanding of the plant genome. Aided by the facilities of the Cell Sciences Laboratory of the Biotechnology Center, A. Lane Rayburn is investigating the organization of genetic material in plant chromosomes and nuclei.

Future Perspectives

The continued development of scientific tools used in genomic research will help the U.S. agricultural community remain competitive in world markets and in position to enter new and specialized domestic and foreign markets. Researchers at the University of Illinois are at the forefront of genomic research, and the new Plant and Animal Biotechnology Laboratory will provide state-of-the-art facilities to maintain this leadership role.

Lawrence B. Schook, professor of molecular immunology, Department of Animal Sciences, and A. Lane Rayburn, assistant professor of cytogenetics, Department of Agronomy

Molecular Identification

Charles R. Vossbrinck

Most of us, scientists included, have the illusion that the degree of detail with which we have identified a living thing is appropriate. For some, it is enough to know that they have trees and flowers growing in their front yards; for others, it is important to recognize whether the trees are oaks or elms and the flowers are daffodils or chrysanthemums.

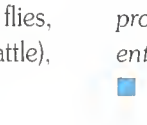
Today's technology allows us to identify any living thing to any level of precision — by using a single cell. This technology uses molecular probes that bind only to the DNA of targeted organisms, is based on gene amplification that multiplies a millionfold the DNA of interest, and involves comparing specific pieces of DNA between organisms.

Molecular identification has two important advantages over conventional techniques of microscopic examination. Identification can be made using a very small amount of material, and is much more accurate than with previous methods — a species, a population, or even an individual can be identified.

Applications. Several applications of this technology are already being used. Individual humans have been identified from a single hair, a drop of blood, or a scraping of skin. Such forensic information has already has been used as conclusive evidence in cases of paternity, homicide, and sexual assault.

Gene amplification has great application in the area of medical diagnostics. Commercial tests are now available to identify, with precision, such disease-causing bacteria as *Legionella* (Legionnaire's disease), *Mycoplasma pneumoniae* (pneumonia), and *Neisseria gonorrheae* (gonorrhea). And in the food industry, bacterial diagnostics, also based on gene amplification, includes tests for *Salmonella*, *Staphylococcus*, and *Listeria*, which all cause food poisoning.

Current research. Research in the Office of Agricultural Entomology at the University of Illinois focuses on both the identification of insects and of the microorganisms associated with insects. Comparison of pieces of DNA has already been used to determine the evolutionary relationships between a group of flies, the Calypterates. This group includes many agricultural and medical pests, such as horn flies (pest of dairy cattle), face flies, tsetse flies (which transmit African sleeping sickness), flesh flies, blow flies, bot flies (parasites of horses and cattle), and house flies.



With a grant from the National Institutes of Health, we are examining opportunistic parasites of humans who have compromised immunological systems. For example, with their impaired immunological defenses, many AIDS patients have become infected with microsporidia, parasites that ordinarily cannot attack humans. We use molecular identification techniques to determine the origin of these microsporidia or which organisms transmit them to humans, and how to prevent their transmission.

Another project uses genetic probes to identify the areas of the southern United States that corn earworms and corn leaf aphids come from and determine if these insect pests are carrying transmissible plant diseases. Unable to survive Illinois winters, they migrate to Illinois from the south each spring. We hope that the information obtained will eventually allow us to make early crop control recommendations.

Other projects under way include the differentiation of populations of corn rootworms and of insect pests of livestock. Future applications of molecular identification are limited only by need, ingenuity, and imagination.

Charles R. Vossbrinck, assistant professor of agricultural entomology

The Plant and Animal Biotechnology Laboratory

University of Illinois at Urbana-Champaign

Dedication September 21, 1991

A Saga of the Plant and Animal Biotechnology Laboratory

Donald A. Holt

Volumes could be written about the historical roots of the Plant and Animal Biotechnology Laboratory (PABL). Time and space, however, prohibit me from telling the whole story about the farmers, agribusiness people, legislators, scientists, administrators, and alumni who played important roles in the building's development. So I simply offer a personal recollection of events related to the PABL.

Awakenings

All that was known about DNA (deoxyribonucleic acid) in the 1950s, when I was a student at the University of Illinois, was that it was an important constituent of genes and chromosomes and had something to do with heredity. In 1956, English scientist James Watson published *The Double Helix*. This now-famous book describes how he and Francis Crick determined the unique structure of DNA, thereby laying the foundation for the modern science of molecular genetics.

Another important development was tissue culture, the ability to keep individual tissues, such as leaf, root, or muscle tissue, separated from organisms, alive and functioning in various media. Scientists were already realizing that unique tissue and cell lines could be selected in tissue culture, just as unique plants and animals are selected in typical plant and animal breeding programs.

As a Ph.D. candidate at Purdue University in the early 1960s, I became aware that molecular genetics was a rapidly expanding field of research. Later, as a Purdue faculty member, I saw that scientists around the world were learning more and more about DNA — how the structural and functional specifications of an organism are encoded in DNA, and how this information is expressed in the growth and development of the organism.

Needs and Opportunities

A vigorous institutional discussion of biotechnology was underway at UIUC when I returned to head the agronomy department in the spring of 1982. More conservative scientists urged caution, correctly judging that the first practical applications of agricultural biotechnology were at least a decade away. Others urged the institution to move aggressively into biotechnology, arguing that at best it would take a decade to build the infrastructure (people, buildings, facilities, equipment, and support services) required to maintain and improve the University's position of international leadership in biotechnology. Social, legal, and philosophical dimensions of biotechnology were hot topics of discussion.

In the agronomy department, we were acutely aware of the need for space. For example, the program of one senior scientist grew to include 20 postdoctoral and graduate students, technicians, and others. Even when we assigned that scientist a suite of laboratories extending from the east to the west side of Turner Hall, only six feet of bench space was available to each person in the program!

We asked what would happen if each of the research programs in Turner hall grew to that size, and found there would be space for only 20 programs, instead of the 80 housed in the building at that time. We definitely had hit the wall. Similarly crowded, inadequate facilities limited programs in other departments. Among other problems, the colleges of Agriculture and Veterinary Medicine lacked the sophisticated animal care and isolation facilities required for biotechnology research.

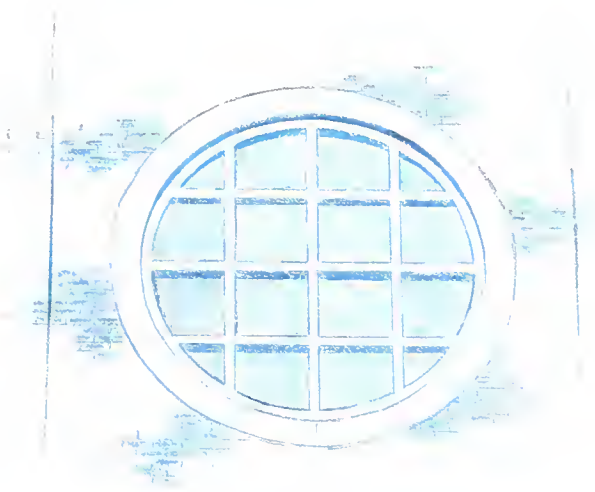
Charting a Course

By the summer of 1982, we were charting the University's course in biotechnology. A state-supported initiative provided two essential support programs — the Recombinant DNA Laboratory and the Cell Science Laboratory, then housed in Morrill Hall. Several new molecular geneticists were employed, including six in the College of Agriculture.

During this time of institutional soul-searching, the University's legislative liaison people were kept busy relaying ideas about emerging biotechnology needs and opportunities to members of the Illinois congressional delegation and their assistants. At the same time, it helped that interest in biotechnology was increasing, both nationally and internationally.

The Rising Tide

In the early 1980s, our efforts to build a strong base of agricultural biotechnology research were rewarded as we successfully competed for outside support.



By the end of 1982, the University had negotiated grants totaling over $1 million with Agrigenetics Corporation, a venture capital firm interested in supporting innovative molecular-genetics and tissue-culture research underway in the agronomy department. With these and other public and private grants, the agricultural biotechnology program was rapidly expanding.

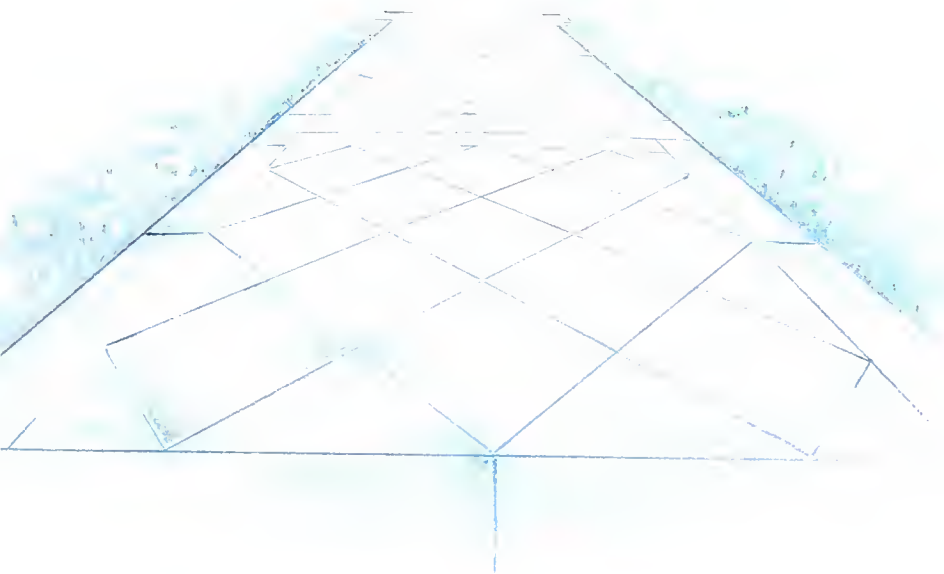
In 1983 the College of Agriculture, in cooperation with scientists in the School of Life Sciences, competed successfully with over 950 public and private institutions and agencies for a Center of Excellence in Crop Molecular Genetics and Genetic Engineering, funded by the Standard Oil Company of Ohio. Success in this competition focused national and international attention on the University of Illinois biotechnology program.

Decisive Moves

Early in 1983, we received word that Congressman Ed Madigan of Illinois was interested in helping us develop a biotechnology research center. We quickly hand-carried a short document to Washington describing "A Proposal for an Agricultural Biotechnology Research Center at the University of Illinois." This was the first of three key documents in which we articulated the dream of the Plant and Animal Biotechnology Laboratory.

In May 1983, Congressman Madigan talked with us about potential federal funding for a major facility. As minority leader of the House Agriculture Committee, he wanted the project to benefit the nation's farmers, agribusiness people, and consumers.

During the meeting, we described the enormous potential of this proposed facility to the nation's food and renewable resources system. We explained that we needed 100,000 square feet of assignable space in laboratories, offices, and support facilities. Given the technical complexity of the proposed building and its programs, we estimated the cost at $300 per square foot, or $30 million dollars. Congressman Madigan said federal funding of the project was possible, and he set in motion the political process that would lead to the Plant and Animal Biotechnology Laboratory.



The Dream Becomes Reality

Our second key document in November 1985 contained the first detailed description of the facility and its potential research programs. "In Quest of Excellence — A Plant and Animal Sciences Research Center" provided a budget for the facility and a list of the Food for Century III projects that were strong evidence of the State of Illinois's commitment to agricultural research.

Questions being raised on the floor of the U.S. House of Representatives were answered in a third key document, "Suitability of the University of Illinois for a Plant and Animal Sciences Research Center." It was enclosed in a letter to a member of Congressman Richard Durbin's staff. Congressman Durbin, as a member of the House Agricultural Appropriations Committee, was to play a key role in providing federal support of the project, as was Terry Bruce, Illinois Congressman from the 19th district.

In the fall of 1986, legislation approved by the House Agriculture Committee, and subsequently approved by Congress, authorized $30 million to build a Plant and Animal Sciences Research Center at the University of Illinois. This landmark legislation resulted from the dedicated effort of the Illinois congressional delegation, led by congressmen Bruce, Durbin, and Madigan, and the personal endorsements of Kika de la Garza (Texas), chair of the House Agriculture Committee, and Jamie Whitten (Mississippi), chair of the House Agricultural Appropriations Committee.

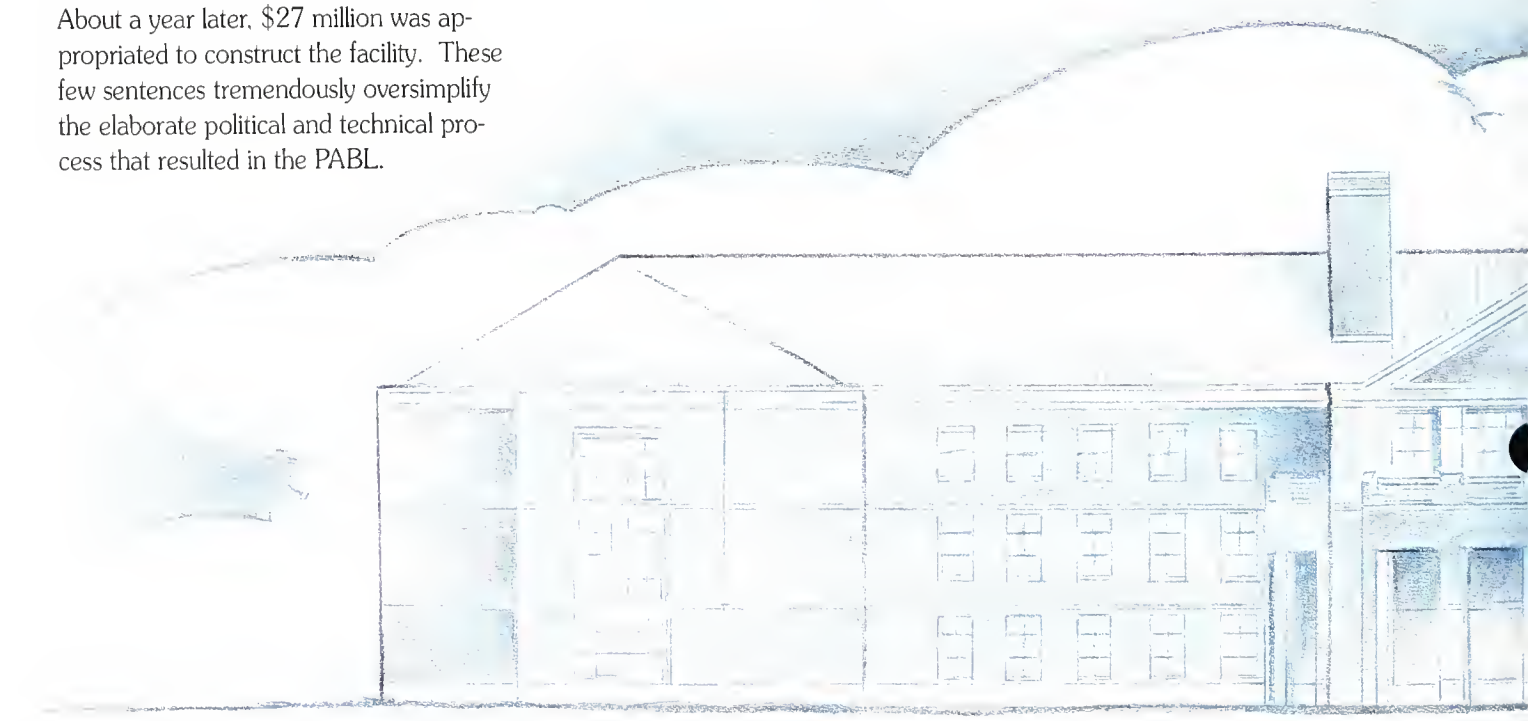
Three million dollars was appropriated to plan PABL in December 1987. The architects were hired and the architectural and engineering design process began. About a year later, $27 million was appropriated to construct the facility. These few sentences tremendously oversimplify the elaborate political and technical process that resulted in the PABL.

The End of the Beginning

As I write this article, the concrete, bricks, stone, mortar, steel, wood, wire, and pipe are in place, configured as the PABL. People, programs, and equipment are moving in. By the time we dedicate the building in September 1991, it will be full of active, productive, innovative biotechnology research programs.

The people of Illinois and the nation, in an act of collective faith in the people of the University of Illinois, provided the money to plan, construct, and operate the PABL. We know they expect something in return. We know that the PABL and the possibilities it opens are not just our dream, but their dream and the dream of many who went before.

Donald A. Holt, associate dean, College of Agriculture, and Director, Illinois Agricultural Experiment Station



Building a Dream

Douglas B. Bauling

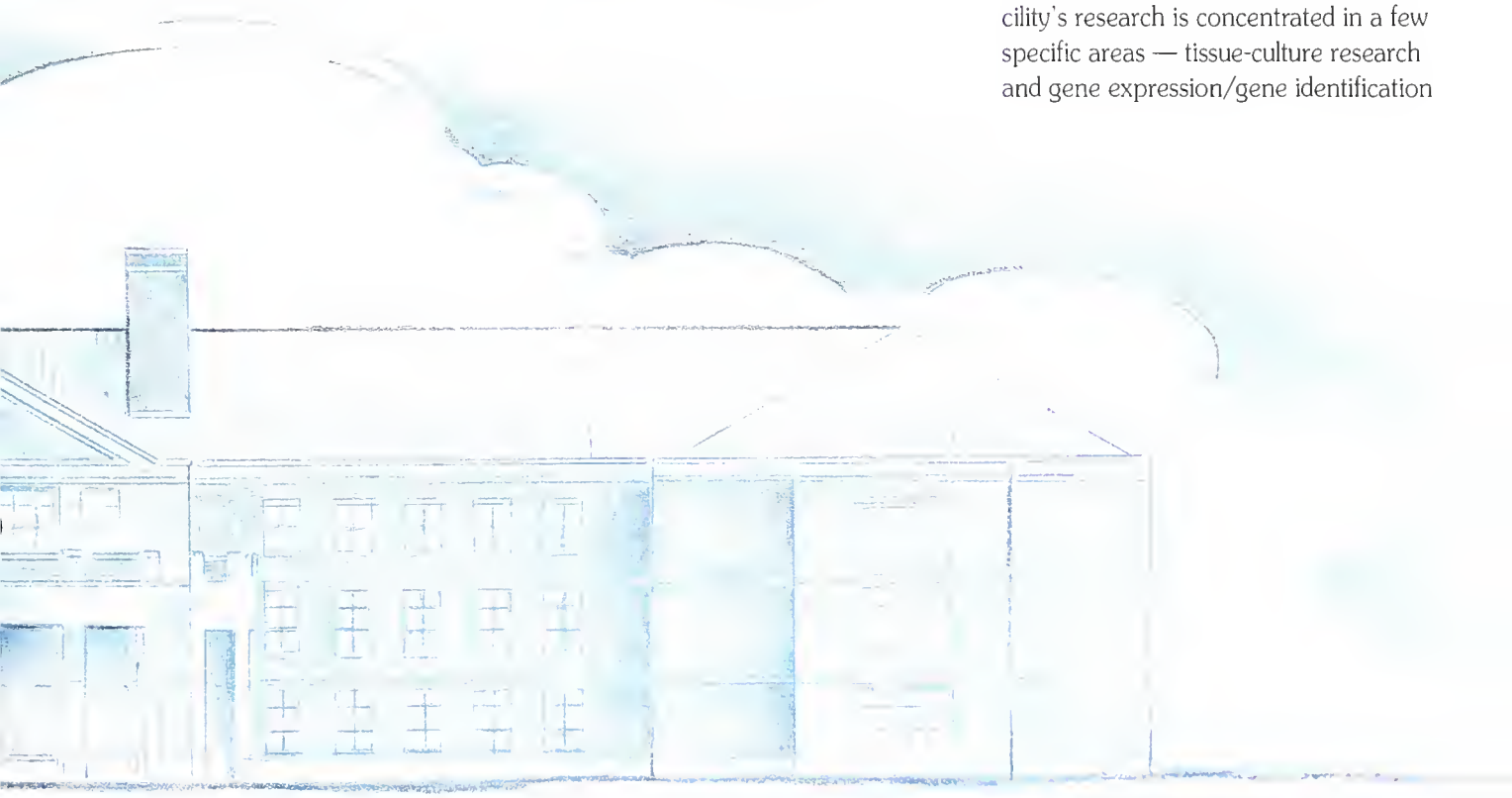
Six years from inception to reality — that's the amount of time it took for the College of Agriculture to realize its dream of the Plant and Animal Biotechnology Laboratory (PABL). This attractive facility, housing more than 100 University and USDA scientists, is a gateway to tomorrow's dynamic agricultural research.

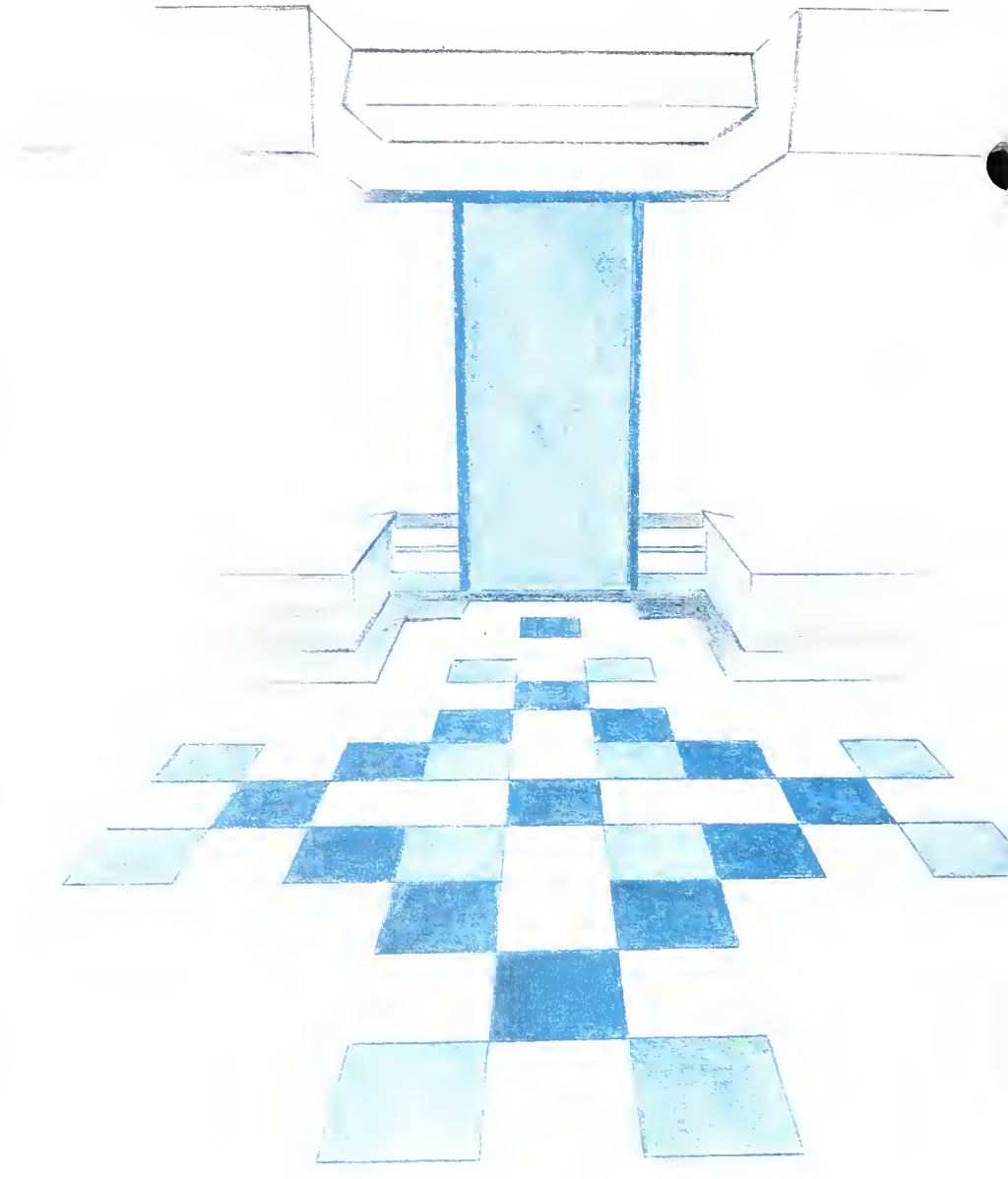
The proposal for a major federally supported facility to support biotechnology in agriculture was formulated in 1985. With support from the Illinois congressional delegation, approval for funding through USDA was successfully pursued. The program statement was developed in 1986 with representatives of the colleges of Agriculture, Veterinary Medicine, and Liberal Arts contributing to the effort. The grant application for planning funds was submitted in July 1986, and planning funds in the amount of $2,853,900 were released that September. The architectural firm of Smith, Hinchman and Grylls Associates, Inc., was selected; and planning began in the spring of 1987. The construction funds grant application was submitted in February 1987, with approval of $26,190,000 in July 1987.

Gilbane Building Company was selected as the construction manager in mid-1988, and bids were received in the fall. Construction began late in 1988 with a November 1990 completion target.

The new facility, designed to support research efforts in designated areas of biological study, is a laboratory with 162,000 square feet of space on four floors. It contains approximately 91,000 net assignable square feet of laboratory-intensive space, with 65 percent oriented toward the support of the plant sciences and 33 percent in support of the animal sciences. The latter includes a research animal facility that will consolidate the on-campus animal research in the College of Agriculture. The remaining space accommodates a conference center that will serve the occupants as well as other College of Agriculture programs.

The biotechnology emphasis of the facility's research is concentrated in a few specific areas — tissue-culture research and gene expression/gene identification





programs. The Biotechnology Center in the School of Life Sciences will operate a cell science laboratory in the facility. The photosynthesis research program, a cooperative program with USDA, will relocate from Davenport and Turner halls to join plant biologists and microbiologists from Life Sciences. They'll form the photosynthesis research unit that will occupy about 20 percent of the facility.

The occupants from the College of Agriculture will include major contingents from the departments of Animal Sciences, Agronomy, and Horticulture, with programs from Plant Pathology, Forestry, and Agricultural Entomology. These programs will occupy assigned space as well as share common space dedicated to specific support functions. Included in the latter are growth-chamber rooms, cold rooms, tissue-culture support facilities, autoclave, dishwasher and dryer areas, and darkroom facilities.

Facilities for specific pathogen-free animal research are separated from the general-use areas. A portion of the large animal research area is specifically designed for a higher level of containment than has previously been available to the colleges of Agriculture and Veterinary Medicine. The facility provides the capability to perform surgical procedures on large farm animals and to hold them in cubicles where they can be isolated from the surrounding environment.

To enhance the utilization of the building, it is directly connected to the lower level of the Animal Sciences Laboratory and connected by tunnel to the basement of Turner Hall. Provisions are in place for a tunnel to Bevier Hall, with plans for construction in another year. These connections will provide convenient access for the many scientists planning research studies in the new building.

Douglas B. Bauling, assistant to the director, Agricultural Experiment Station, and planning engineer

Animal Research Facilities

William L. Heckt

The University of Illinois is a leading research institution and maintains a USDA license to conduct animal research. In the College of Agriculture, research facilities house laboratory animals and production farm animals used in studies supporting research, teaching, and extension programs.

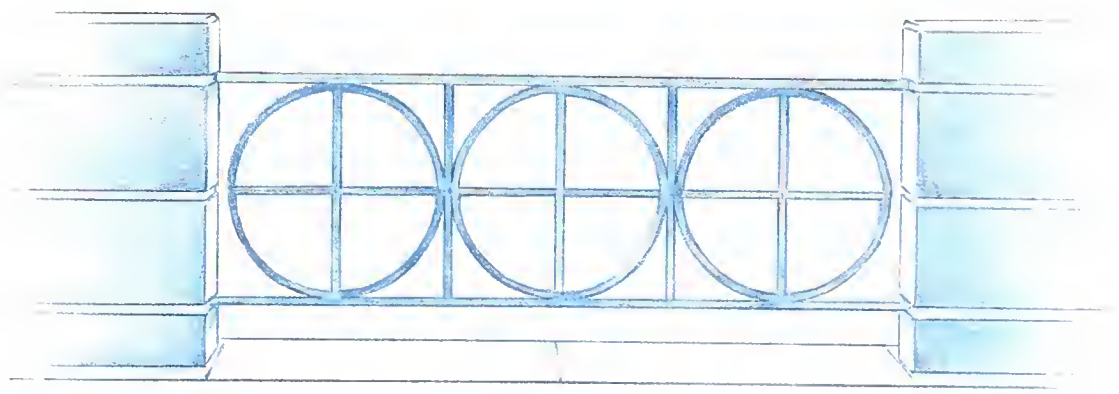
Federal specifications for animal facilities cover design and materials, and include recommendations for ventilation rates, temperature, humidity, lighting levels, and noise control. They ensure that facilities are designed to optimize observation of the animals and sanitation in the facilities, and provide comfortable, environmentally controlled living space for animals.

More importantly, the level of quality control needed for experiments is quite often higher than that required by regulations. Researchers plan, monitor, and assess how a variety of possible variables (environmental, social, health, and experimental) affect the animals. Control of these variables is important for optimal research results. For example, animals that carry genes experimentally transferred from a different breed or species may require specialized care. Some could be sensitive to "normal" environmental conditions and may have decreased resistance to conventional pathogens, as well as normal organisms.

Newly constructed animal research facilities in the College of Agriculture were designed with these factors in mind and provide a controlled physical environment suitable for a wide range of animal species and research needs. The 30,000-square-foot animal research area is located on two floor levels that separate the agricultural farm animal area from the small laboratory animal research activities.

The farm animal area contains poultry rooms designed for housing chicks and laying hens; a room for intensive work with large animals; and a large animal aseptic surgery unit containing eight stalls for cattle, pigs, sheep, or goats. The surgery is equipped with a hydraulic table, built-in piping for anesthetic gases, and a procedures area containing equipment for handling and culturing cells and embryos.

One unique feature of the animal facility is the extensive use of the "Illinois Cubicle" for livestock housing. Seven animal rooms are divided into a series of 36 smaller, individually controlled spaces for isolating single animals or small groups of animals from one another in nearly



equivalent environments. This area was designed to contain genetically altered organisms. Equipped with an electronic security system to control and monitor entry into the facility, the area contains locker rooms with separate showers for entering and leaving the research area. Laboratory rooms with bench space, fume hoods, and biosafety cabinets are located on both the entry and exit corridors. A large steam sterilizer, waste incinerator, small animal equipment washer, and walk-in cold rooms are fixed equipment within this space.

The small animal research area has 19 animal rooms designed for housing mice, rats, guinea pigs, rabbits, and other experimental animal species. Three of the rooms are divided into a total of 15 individually ventilated and temperature controlled cubicles for projects involving small numbers of animals. The area contains a research diet preparation room with scales, mixers, and cold storage; a small animal aseptic surgery; and six rooms with lab benches and equipment to conduct laboratory procedures within the facility.

The entire animal research area is ventilated with air that passes through high-efficiency filters, making it free of dust and smoke. The air can be humidified or dehumidified for animal comfort and research need. The air is not recirculated, so potential contaminants generated in one room cannot enter another through the ventilation system. The ventilation in each animal room can be turned off when the room is not in use, or when it is being cleaned and fumigated. The air temperature and the light cycle can be individually programmed for each animal room.

These features provide the flexibility to accommodate a large variety of research needs. They combine with a good architectural plan and physically strong construction, based on the need for heavy use and a high level of sanitation, to provide an outstanding facility for agricultural and biomedical research.

William L. Heckt, assistant to the director, Agricultural Experiment Station

RFLPs and Corn Improvement

John W. Dudley

Restriction fragment length polymorphisms (RFLPs) are described in a sidebar by Rocheford. For improving corn, RFLPs can be considered "mile-markers" of specific sites on plant chromosomes. Different plants may have different forms of any one marker. By crossing two corn inbreds or genetically uniform lines used as parents of hybrids that each have a different form of the marker, segregation of the marker can be seen in the subsequent generations. For such traits as grain yield, corn-borer resistance, or kernel quality (percent of oil or protein), it has not been possible to identify individual genes or to determine the number of genes responsible for differences in these traits between inbreds.

If two inbreds have different forms of a marker and one of the traits (for example, corn-borer resistance) also differs, it can be determined whether a gene controlling corn borer resistance is located near the marker when the trait is measured on each subsequent plant or its progeny. By using four to ten markers on each chromosome, the number of genes controlling the trait can be determined. Until the development of RFLPs, each trait was known to be controlled by several genes. The effects of each gene were so small relative to environmental effects, however, that individual genes could not be identified and manipulated by plant breeders.

Work in our laboratory and several others has demonstrated the utility of RFLPs to identify genes with significant effects on grain yield and its components. Our challenge has been to develop effective ways to incorporate this technology into corn breeding programs. Several possible ways of using this technology are currently being evaluated. When adding single genes, such as Ht1, a gene for resistance to northern corn leaf blight, into a commercially usable line, RFLPs can reduce the time required to regain the genotype of the line being improved from six generations to two or three. For traits such as corn-borer resistance for which single genes previously have not been identified, identification of two or three markers associated with genes for resistance should allow use of simple procedures for adding corn-borer resistance to commercially used inbreds. We are currently devising procedures for using RFLPs to improve yield.

RFLP technology will not replace proven corn breeding procedures. It is a tool, however, that will enhance the efforts of corn breeders and speed the development of higher quality, higher yielding, more stable corn hybrids.

John W. Dudley, professor of plant genetics, Department of Agronomy

Restriction Fragment Length Polymorphisms

Torbert R. Rocheford

Corn breeders have traditionally developed improved varieties by selecting plants with desirable phenotypes (visual appearance). A plant's phenotype, however, is determined not only by its genotype (genetic composition) but also by the environment in which it is grown.

Because effects of the environment may mask effects of the plant's genotype, the phenotype may provide an inaccurate measure of a plant's actual genetic composition or potential. Consequently, to identify genetically superior plants, very elaborate, expensive plant-breeding techniques are used. By providing direct information about the genetic material of plants, restriction fragment length polymorphism (RFLP) technology may help overcome some of the problems associated with traditional methods of identifying genetically superior plants.

DNA consists of nucleotide bases that comprise genes (coding regions) and the regions between genes (noncoding regions). Variation in the DNA sequence composition of individual plants can be detected by restriction endonucleases. These enzymes recognize specific short (four- or six-) nucleotide base sequences of DNA and cleave the DNA strands at these points. Using electrophoresis, an electrical current is produced across the length of an agarose gel. Because DNA is negatively charged, DNA fragments migrate to the positively charged end at a rate proportional to their relative size.

The fractionated DNA is transferred to nylon membranes by a process called Southern blotting. Previously cloned pieces of DNA from regions of the plant genome under study are labeled with radioactive or nonradioactive labeling methods. The labeled pieces of DNA are hybridized or annealed to the fractionated DNA on the membrane. The membrane is then exposed to X-ray film to detect the regions where the cloned DNA hybridized to the fractionated DNA. The patterns on the film will reveal restriction enzyme-generated hybridization fragments of different lengths (polymorphisms), thus the basis for the term "Restriction Fragment Length Polymorphisms" (RFLPs). Also known as molecular markers, RFLPs mark different chromosomal regions.

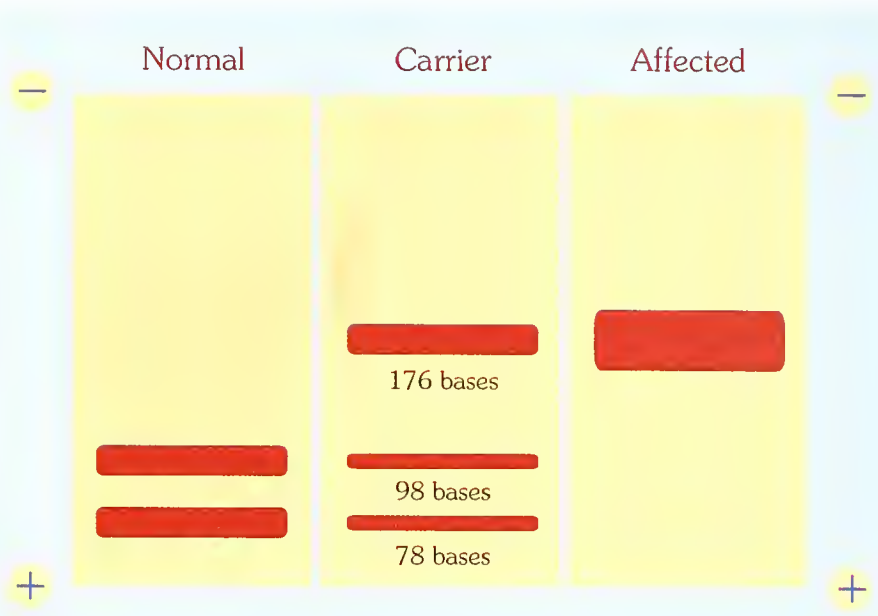
Through evaluation of genetic progenies segregating for RFLP markers and agronomic traits of interest, RFLP markers can be associated or linked with genes controlling important traits. For plant breeding, DNA can be isolated from experimental plants and their RFLP patterns determined with the DNA clones that are linked to important traits. Plants with the desirable RFLP pattern are identified and selected for further breeding, regardless of the environment in which the plants were grown.

Torbert R. Rocheford, assistant professor of corn breeding, Department of Agronomy

In the DNA sequence analysis here, each band represents a different allele of the same gene encoding maise seed protein.

Diagnosing Carriers of Genetic Diseases

James L. Robinson



Electrophoretic patterns diagnostic for normal, carrier, and affected genotypes for bovine citrullinemia. Here, the genes and gene fragments separate in an electric field. Normal animals have two short segments that result from cutting the amplified DNA segment. Affected animals (homozygous recessives) have one long uncut segment because the mutation prevents the cut. Carrier animals (heterozygotes) have three segments (one normal sequence and one mutated sequence).

Genetic diseases or inherited disorders occur in all animal species. Intense selection for improved animal performance, however, may inadvertently increase the frequency of undesirable traits. Because most genetic diseases in domesticated species are inherited as autosomal recessive traits, and carriers generally give no outward indications, the undesirable trait can be spread widely and covertly.

When carriers of any specific condition become prevalent, matings between carriers occur at a high frequency, resulting in affected offspring (homozygous recessives) that will often die prematurely. Identifying and progressively eliminating carriers from a species or breed constitutes an incremental method for improving animals useful to humans.

Biotechnology offers the promise of rapid, economical detection of carriers of genetic diseases. Similar methods are being developed to diagnose genotypes, such as normal, carrier, or affected, for conditions inherited by humans. It is crucial to identify the nucleotide change in the DNA (genetic material) structure responsible for the condition. The changed nucleotide sequence can often be distinguished by using one of hundreds of restriction enzymes that cut the DNA at specific points. The polymerase chain reaction (PCR) can be used to amplify the sequence that contains the mutation before treatment with the appropriate restriction enzyme.

These methods already permit diagnosis of the genotypes for bovine citrullinemia, a genetic disease of Holstein-Friesian cattle. In Australia, one of every 250 calves born is affected (homozygous recessive) and dies of neurological dysfunction within five days of birth. Among U.S. Holstein cattle, carriers exist; but their frequency, expected to be low, is presently unknown.

The diagnostic protocol consists of

- obtaining a blood, semen, or tissue sample of DNA from the test animal;
- extracting the DNA from the sample;
- amplifying (using PCR) a nucleotide sequence that contains the site of the mutation;
- treating the amplified sequence with a restriction enzyme that cuts only the normal sequence; and
- electrophoresing the resultant DNA to reveal the number and size of DNA segments present.

Electrophoresis is the movement of molecules through a fluid or gel under the action of an electrical current. The figure shows the electrophoretic patterns diagnostic for the normal, carrier, and affected genotypes of bovine citrullinemia.

James L. Robinson, professor of biochemistry, Department of Animal Sciences

Animal and Plant Transformation: The Application of Transgenic Organisms in Agriculture

Matthew B. Wheeler, Stephen K. Farrand, and Jack M. Widholm

A transgenic organism carries in all its cells a foreign gene that was inserted by laboratory techniques. Each transgenic organism is produced by introducing cloned genes, composed of deoxyribonucleic acid (DNA) from microbes, animals, or plants, into plant and animal cells. Transgenic technology affords methods that allow the transfer of genes between different species.

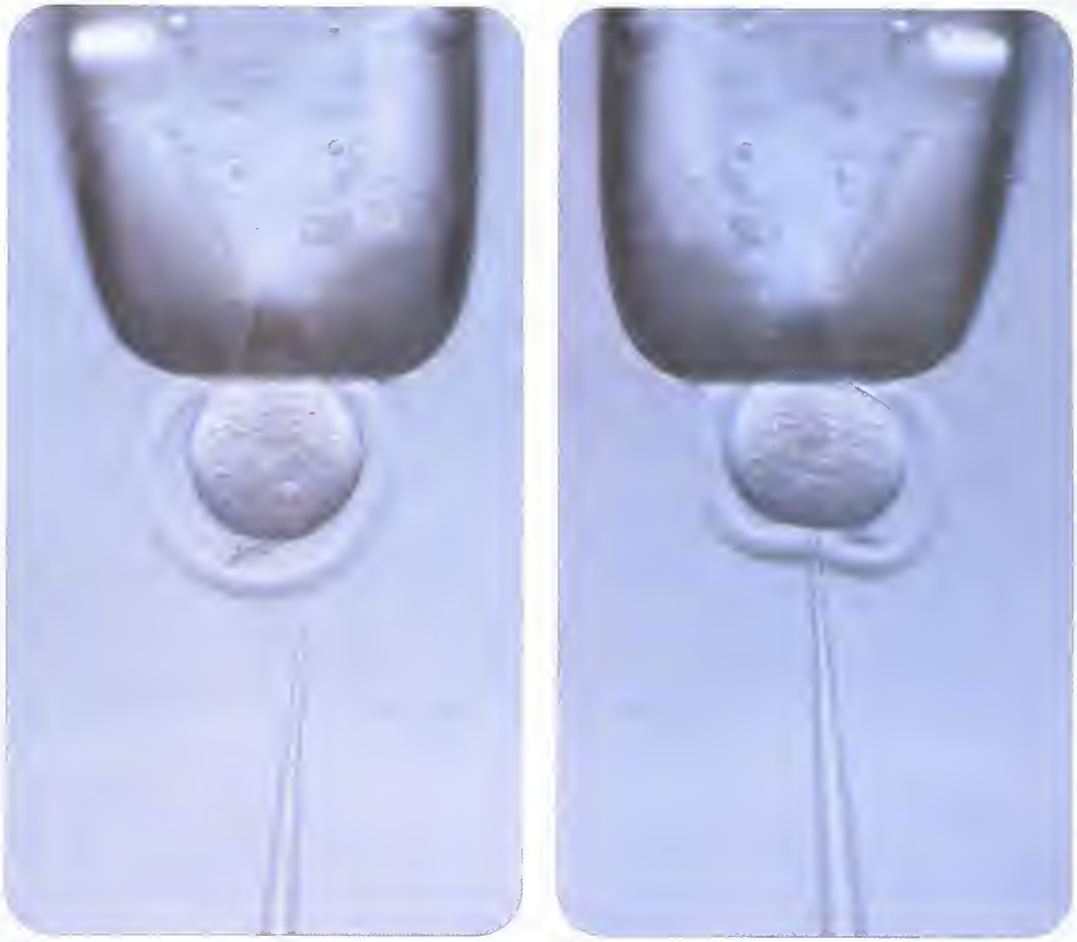
Animal Transformation

Through transgenic animal transformation, new genetic information is introduced into an animal in *one* generation without compromising or limiting the overall pool of genetic information. Transgenic animals are produced by inserting genes into embryos prior to birth. Each transferred gene is assimilated by the genetic material or chromosomes of the embryo and subsequently can be expressed in all tissues of the resulting animal. The objective is to produce animals which possess the transferred gene in their germ cells (sperm or ova). Such animals are able to act as "founder" stock to produce many offspring that carry a desirable gene or genes.

Transgenic animals have been produced by three methods: microinjection of cloned gene(s) into the pronucleus of a fertilized ovum, injection of embryonic stem cells into embryos, and exposure to retroviruses. The third method is not discussed in this article.

The first method is the one that is most widely and successfully used for producing transgenic mice. After mi-

To produce transgenic mice, Matthew B. Wheeler microinjects DNA into the pronucleus of one-cell embryos.



Injection of cloned DNA into embryos. One-cell embryo is positioned for micro-injection into the pronucleus (left). The plasma membrane has been pierced, and the tip of the needle remains inside the pronucleus, while DNA is expelled from the needle, causing the pronucleus to swell visibly.

croinjection, the recently fertilized single cell embryos are removed from the animal. Micromanipulators on a specially equipped microscope are used to grasp each embryo. A glass pipette drawn or pulled to a fine point immobilizes the embryo on one side, as shown in the photos to the right. On the opposite side, the foreign DNA is injected into the embryo's pronucleus — either of two nuclei (male or female) containing half the chromosomes of a fertilized ovum — with a second finely drawn injection needle. After the injection, the embryos are transferred back into the hormonally prepared or pseudopregnant recipient females or foster mothers. The recipients follow normal pregnancy and deliver full-term young. This method is presently the most efficient for generating transgenic animal lines: about 1 to 4 percent of the injected embryos result in a transgenic offspring.

The second method involves microinjection of embryonic stem (ES) cells derived from the inner cell mass of blastocyst-stage embryos (about 7 days postfertilization) into embryos to produce "hybrid" embryos of two or more distinct cell types. The ES cells are able to produce all tissues of an individual. Once isolated, ES cells may be grown in the lab for many generations to produce an unlimited number of identical cells capable of developing into fully formed adults. These cells may then be altered genetically before being used to produce embryos. When these transformed cells participate in the formation of sperm and eggs, the offspring that are produced will be transgenic. Results have shown this method to be promising for producing transgenic mice. Studies are presently under way at the University of Illinois Department of Animal Sciences to develop ES cell lines for livestock species such as swine, cattle, and sheep.

These methods, which enable the insertion of foreign genes into embryos, have provided the tools for producing new strains or breeds of animals that carry new, beneficial genetic information. These technologies do not produce new species but work within the established genetic framework of existing species to improve them. Some new strains developed include leaner, more feed-efficient, faster-growing swine containing additional copies of the growth hormone gene, and mice containing the regulatory elements of the human immunodeficiency virus (HIV) genome. The latter are used as a noninfectious animal model for the study of AIDS.

The scope of the information acquired from transgenic animal technology is pertinent to virtually all areas of modern agriculture and biomedical science — cancer research; immunology; developmental biology; gene expression and regulation; and models for human genetic diseases such as muscular dystrophy.

Lou Gehring's disease, and sickle cell anemia. Potential applications for transgenic animals include manipulation of milk composition, growth, disease resistance, reproductive performance, and production of pharmaceutical proteins by livestock.

Plant Transformation

There has been much excitement in the last few years about our ability to genetically engineer plants using the new techniques of gene isolation and insertion. Paired with standard methodologies of plant tissue culture and plant regeneration, these new techniques allow us to construct transgenic plants that contain and express a single, well-defined gene from any source — microbe, animal, or other plant species. The transgenic plants, usually normal in appearance and character, differ from the parent only with respect to the function and influence of the inserted gene.

This directed genetic engineering of plants requires that genes of interest are available, that the gene be introduced into plant cells capable of regenerating into intact plants, and that the gene carries with it a selectable marker so that the transformed plant cells can be isolated from a large population of untransformed, normal cells. Finally, the transformed plant cell must retain its capacity to regenerate. Certain species such as tobacco and petunia regenerate plants quite easily, making transgenic plants readily obtainable. Although corn, soybean, and wheat — the primary agricultural crops of Illinois and the Midwest — are more recalcitrant to these manipulations, progress is being made toward routine transformation and regeneration of transgenic progeny of these species.

Several techniques can introduce genes into plant cells. Perhaps the most successful method involves the pathogenic bacterium *Agrobacterium tumefaciens*, which has the innate ability to transfer DNA to plant cells. In nature, this transfer results in formation of plant tumors (crown galls) at the infection site. Molecular biologists, however, have disarmed this bacterium and constructed domesticated strains that no longer cause tumors but transfer any DNA of interest to plant cells. The major disadvantage of the highly efficient *Agrobacterium* system is that it does not work with all plant species, most notably the cereals.

Other techniques use physical or chemical agents to transfer DNA into plant cells. Protoplasts, plant cells that have been stripped of their protective cell walls, will take up pure DNA when treated with certain membrane-active agents or with electroporation, a rapid pulse of high-voltage direct current. Once inside the cell, the DNA is integrated and the foreign gene will express. These two techniques largely depend upon the development of protoplast systems that retain the capacity to regenerate intact plants. Transgenic corn, rice, and soybean have been produced with these techniques, especially electroporation. Success rates, however, are low, and the techniques not very reproducible.

DNA can also be microinjected into target plant cells using very thin glass needles in a method similar to that used with animals. Microinjection, however, has produced only a few transgenic plants. The technique is laborious, technically difficult, and limited to the number of cells actually injected.

Biolistics, a new method, involves accelerating very small particles of tungsten or gold coated with DNA into cells using an electrostatic pulse, air pressure, or gunpowder percussion. As the particles pass through the cell, the DNA dissolves and becomes free to integrate into the plant-cell genome. This improbable technique actually works quite well and has become, along with electroporation, one of the methodologies of choice. Biolistics has the advantage of being applicable to whole cells in suspension or to intact or sliced plant tissues. For example, plant meristems or tissues capable of regeneration can be targeted directly. Unlike transformation or electroporation, the technique does not require protoplasts or even single-cell isolations. Using biolistics, transgenic corn and soybean plants have been produced that contain heritable copies of the inserted gene.

Only a few genes of agronomic importance have been inserted into plants: genes conferring resistance to certain insects and viruses and also those conferring tolerance to broad-spectrum herbicides. The latter result in increased herbicide specificity, allowing the farmer to use more effective, environmentally safe chemical agents. More recently, a gene has been introduced into tomato that delays overripening and prolongs shelf life of the fruit.

Other traits of interest include those associated with grain quality. Genes to increase the content of amino acids such as lysine, methionine, and tryptophan in seed will increase nutritional value, thereby decreasing the need for amending grains with costly feed supplements.

All traits discussed here are associated with expression of single genes. But many important agronomic traits such as yield and lodging are not well understood and are controlled by many genes. Manipulating such polygenic traits by genetic engineering will require further research and the development of techniques for isolating, reconstructing, and transferring complex blocks of genes. Extensive and promising research is being conducted about additive disease resistance and stress tolerance, important polygenic traits. Plant genetic engineering is thus moving slowly but steadily from the laboratory bench into the field.

Matthew B. Wheeler, assistant professor of animal sciences; Stephen K. Farrand, professor of plant pathology and microbiology; and Jack M. Widholm, professor of plant physiology, Department of Agronomy

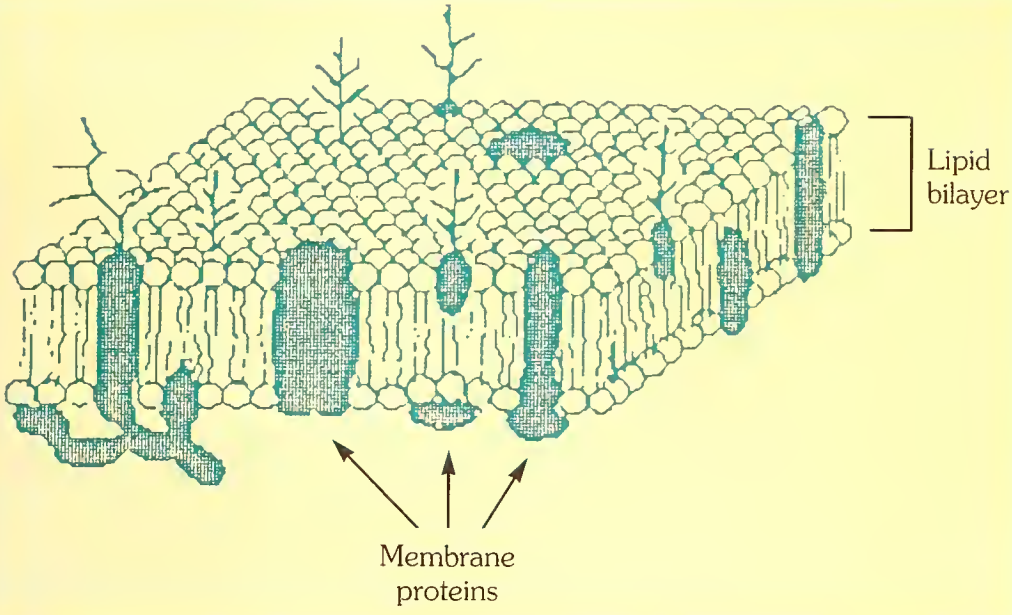


Diagram of the structure of biological membranes, showing the lipid bilayer and membrane-associated proteins.

Source: Adapted from *Biochemistry and Function of Vacuolar Adenosine-Triphosphatase in Fungi and Plants*, B.P. Marin, ed. (1985).

Biotechnology and Plant Membranes: Future Implications

Donald P. Briskin

Membranes define the outer boundary of plant cells and the structure of their internal organelles. In this role, membranes regulate the flow of materials between cells and their environment as well as their internal compartments. These materials can include mineral nutrients acquired from the soil and metabolites important for crop growth and development. At the whole-plant level, transport across membranes can serve to define allocation patterns for the products of photosynthesis and metabolism, which can determine the quantity and quality of crop yield.

Membranes are composed primarily of lipids and proteins. The bilayer lipid arrangement defines the plane of the membrane to which proteins are associated (see figure). The lipid portion of the membrane can represent a substantial barrier to material flow, but the proteins associated with the membrane impart the means for selective transport and accumulation of solutes. This function is defined by the structure of the transport protein, which is, in turn, a reflection of its primary amino acid sequence encoded by its respective gene.

With current advances in molecular biology, this approach would appear to represent a powerful tool for modification of membrane transport processes, with the ultimate goal being the development of improved crop cultivars. But there is a paucity of basic knowledge about how membrane transport systems operate and are regulated. Therefore, before biotechnology of membrane processes can become a reality, much work is needed to define the function and structure of membrane transport proteins at the molecular level.

At the University of Illinois Agricultural Experiment Station, work is being conducted to understand the biochemistry of the transport system involved in nitrate uptake by maize roots. This mineral nutrient represents a major limiting factor for determining maize growth and yield as demonstrated by the increase in yield for maize grown in Illinois with the advent of nitrogen fertilizer application. Our work focuses on not only understanding which properties of this transport system determine its function and regulation but also on elucidating the factors that limit its efficiency. The ultimate goal is to provide important information about this transport system, so that its activity can be modified through gene manipulation to produce crop plants with greater efficiency for nitrate acquisition and allocation. Potentially, then, novel maize cultivars could be developed that require less nitrogen fertilizer for a given yield and hence realize higher productivity.

Donald P. Briskin, associate professor of plant physiology, Department of Agronomy

Genetic Transformation of Crop Species

Angus G. Hepburn

Because corn and soybeans are the two major feed crops in Illinois, there is great interest in genetically transforming these species for such traits as increased protein quality, seed yield, or altered lipid content. Unfortunately, the techniques that work well with tobacco or petunia, so-called "model" species, do not work as well with corn and soybeans. Researchers are trying to determine the cause of this reduced efficiency. The problems arise mainly from difficulties in delivering DNA containing the desired gene to plant cells that are capable of regenerating into whole plants. In the model plant species, disruptions (separations into small clumps of cells, single cells, or protoplasts) are an integral part of the successful transformation process, but when comparable disruptions are applied to tissues from the crop species, the fragmented tissues are incapable of regenerating whole plants. Thus, any DNA delivery technique that requires such disruptions to the crop species will be of little value.

Our research uses two related, complementary approaches to overcome these problems. One approach is to develop delivery of DNA to organized cell clumps or tissues that retain the ability to regenerate whole plants. The major barrier here is the rigid cell wall that surrounds the plant cell. Purified DNA must pass through this barrier to reach the cell membrane and enter the cytoplasm and, eventually, the nucleus where DNA can be integrated into the plant cell genome.

Recent developments in electroporation (using a pulsed electrical field) or the new microprojectile technology are encouraging. Under the right conditions, it appears that the forces involved can move the DNA through the cell wall without significant damage to the genetic material. Attempts to get *Agrobacterium tumefaciens*, the biological vector system, to deliver DNA to regenerable cells also show success, at least for soybeans.

Assistant biologist David R. Duncan selects a culture for examination.

The second approach uses techniques to disrupt the tissues of the crop species so that the highly efficient protocols used for transformation of the model species are also effective, while allowing the disrupted cells to retain the capability of regeneration. Again, recent advances in tissue-culture technology are proving invaluable for soybean transformation, and progress is being made in developing comparable systems for corn.

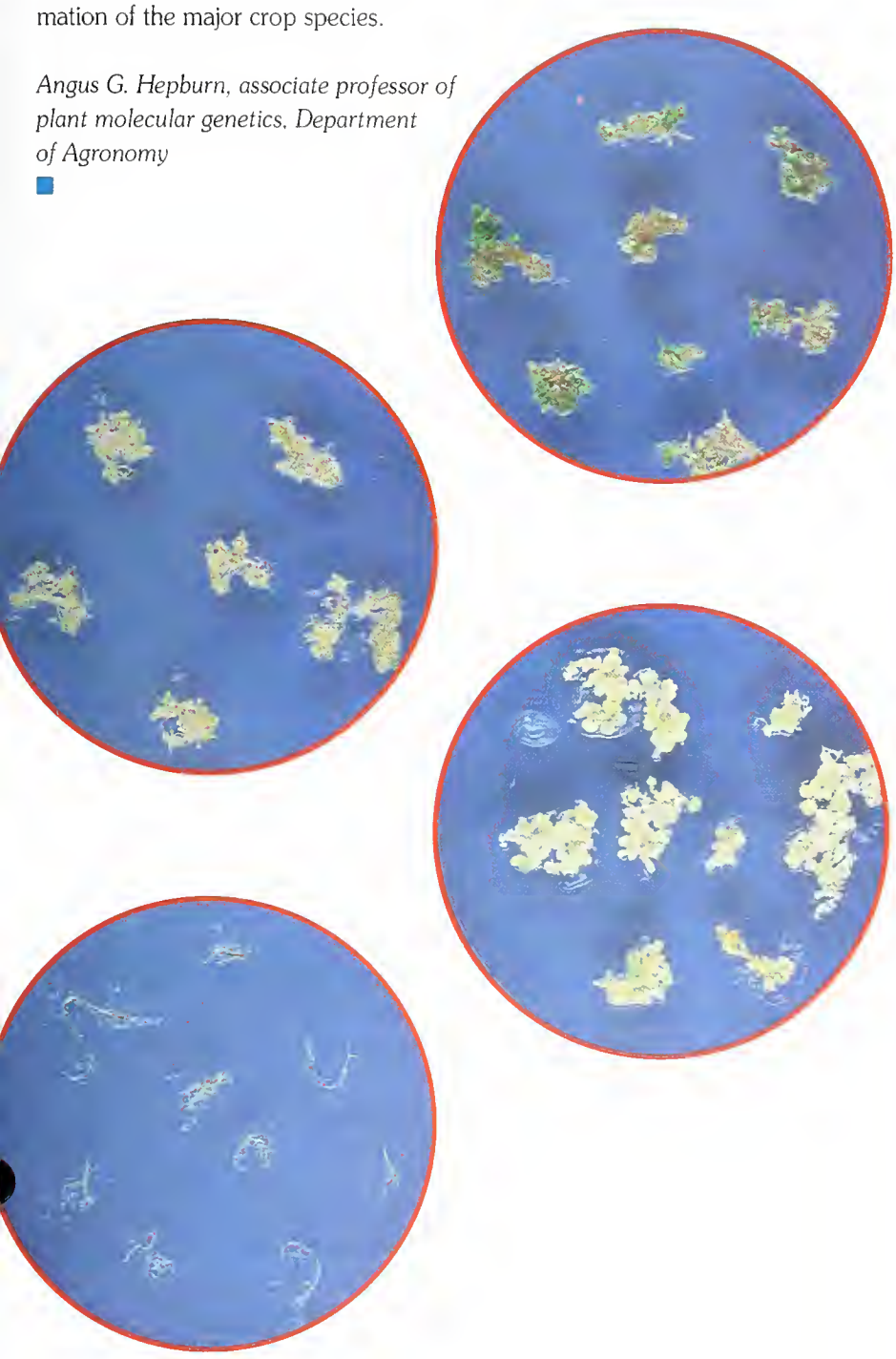
Still another problem has been found in detecting transformed cells or tissues in the mixture of transformed and untransformed cells produced in a typical transformation experiment. Usually an antibiotic-resistance selection marker (for example, kanamycin resistance) is included in the vector molecule with the desired gene for plant improvement. Such an approach gives a highly efficient selection system for the model species. Unfortunately, the sensitivity of crop species to the most common antibiotic-resistance selection markers is low or variable so that only a low-level enrichment is obtained. When transformation efficiency is one in 1000 or lower, even a 100-fold enrichment for transformed cells or plants requires a considerable investment in plant screening and analysis. Much effort has therefore gone into developing better selection markers for use with crop species.

The antibiotic Hygromycin B seems to be the best selection candidate for soybeans and the herbicide Basta, the best for corn. Resistance genes for both have been found in bacteria and modified to work in plants. The chemicals appear to discriminate well between transformed and untransformed cells when the two are mixed and used for selection. Although neither is as clean in its corresponding crop as is kanamycin in the model species, the enrichment is enough to make the screening for transformed cells time and cost effective. Because of subtle differences in the ways different

plant species control gene expression, the selection markers are being tailored to specific crops to ensure that they are expressed at the highest possible level. This practice has been found to compensate for reduced levels of expression resulting from species specificity of expression-controlling elements.

With these improvements, the future looks promising for successful transformation of the major crop species.

Angus G. Hepburn, associate professor of plant molecular genetics, Department of Agronomy



Improving Photosynthesis by Gene Engineering

William L. Ogren

In photosynthesis, a plant uses sunlight to remove carbon dioxide from the atmosphere and converts it into sugar and starch. The plant uses these for growth of seeds, fruits, tubers, or other plant parts of economic value, such as leaves, roots, and stems. Because crop productivity increases when photosynthesis occurs more rapidly, much research is directed toward improving this process.

One approach being taken by a USDA research team at the University of Illinois Department of Agronomy is to speed up the first step of photosynthesis. Five years ago, this team discovered an enzyme that governs the rate at which leaves absorb carbon dioxide. The gene that determines the structure of this enzyme, and thus the enzyme's activity, was then obtained. Using genetic engineering, several different changes were made in the gene to alter the properties of its enzyme product.

It cannot be predicted how changes in enzymes will affect their activity. Because enzymes have highly organized structures, changes usually result in less activity. In this case, however, one of the altered enzymes had more activity than normal. Attempts are now being made to incorporate the modified genes into plants, using standard methods of genetic transformation. Following transformation, photosynthesis measurements of the transgenic plants will be made. Such tests will determine the possibility of improved plant productivity by modifying this component of photosynthesis.

William L. Ogren, research leader, USDA/ARS, and professor of agronomy

A comparison of woody transplants rooted in vitro (left) or removed from culture and rooted ex vitro in soil (right). A video image analysis system records the superior root structure produced ex vitro.

Bridging Plant Biotechnology and Field Research

Mary Ann L. Smith

New biotechnological strategies to manipulate plant germplasm in vitro have advanced at a staggering rate. Despite the intensive research interest in plant biotechnology, scientific progress and commercial exploitation frequently have been blocked at the crucial "transition" stage — from novel plant regenerates exhibiting superior growth or stress tolerance in the laboratory to field-proven crop plants.

Biotechnology in Horticulture

Robert M. Skirvin

Horticultural scientists study crops that are used for food, drugs, or aesthetics. Many of these crops are unique or so highly specialized that they are no longer propagated sexually by seeds but rather asexually by such methods as cuttings, grafting, layering, and tissue culture. Seedless grapes, potatoes, maple trees, and roses are some examples of crops that are propagated by some or all of these methods. Although some cultivars are very well known and widely grown, problems related to disease susceptibility, fruit or flower quality, or growth habits arise occasionally.

Traditional sexual-breeding programs can improve some of these crops. The process can be slow, however, especially in tree-breeding programs.

Many of our most popular flower, fruit, and vegetable cultivars are very old. The public often rejects a new cultivar in favor of a better-known cultivar that has endured. The asexually propagated 'Bartlett' pear, for example, introduced in 1770, remains the world's standard for pear quality. Because most new cultivars fail this test, they remain as local cultivars or are discarded.

Another method to improve cultivars is to screen "sports" or mutations that occur naturally, but rarely, on cultivars grown in a field, greenhouse, or laboratory. For example, the green-fruited 'Bartlett' pear sported to yield the red-fruited 'Red Bartlett'. Although this natural variability is useful for plant improvement, the process is random and many plants must be inspected to find a desirable mutant type.

Variability is a universal feature of plant tissue-culture, a method whereby plant parts are grown aseptically on artificial medium. Variation that develops under tissue-culture conditions is now called somaclonal variation. In tissue culture, whole plants can develop from single cells under the proper stimuli of growth regulators, growing medium, and light. Although the precise cause of somaclonal variation remains unknown, its induction and use have become important research topics.

The exploitation of natural and induced variation seems especially applicable for improving older asexually propagated cultivars like 'Bartlett' pear. During the past 200 years, the clone has been exposed to natural radiation — ultraviolet and cosmic rays — and various sprays and pollutants. These exposures have probably resulted in mutations that stabilized as islands or regions within the body of these plants. When a cultivar possesses mutant cells (natural or artificially induced), whole plants derived from these cells may express the mutation and be classified as somaclones.

The common obstacles to this transition are twofold: 1) characteristics evident in cell culture may not be expressed at the whole-plant level under natural production conditions, and 2) rooting and acclimatization of in vitro plants to field or greenhouse conditions may result in serious losses in plant survival rates and quality. Research efficiently linking laboratory biotechnology and traditional field-performance research is needed to foster rapid, practical realization of the gains offered through biotechnology. To enhance this transition, we have developed whole plant microculture (WPMC) intermediate testing systems and video-image analysis systems.

A WPMC system can provide a small-scale, efficient, highly controlled test environment for regenerates from cell culture, to verify that traits selected at the cell level are still expressed in the whole plant. For example, definitive and reproducible detection of superior salt tolerance traits for turfgrasses, tomatoes, and greenhouse floriculture crops have been achieved in rigorously controlled WPMC systems. With the aid of a computer, a video camera processes images of test microplants and allows subtle detection of plant responses to salt stress in the root and shoot zones. The image analysis system automates collection of data about plant growth, development, and disease symptoms. Traits evaluated in WPMC have correlated well with traits measured in vivo in field or growth chamber tests.

The transition from biotechnology research to production can also be obstructed at the stages of rooting and acclimatization, so that regenerates from culture can be evaluated in vivo. In some cases, the regenerated plants that survive transition have abnormal growth and poor tolerance to environmental stress.

Quantitative and qualitative differences in root character after in vitro and ex vitro rhizogenesis, or rooting initiation, dictates plant survival and has long-term repercussions for mature woody specimens that we originally produced in vitro. The nondestructive advantage of using images to evaluate plant quality has allowed us to identify specific factors that affect regenerated clones' chances for survival. This information provides new clues on how to manipulate in vitro strategies to ensure ultimate production of superior plant selections for either field or landscape conditions.

Research systems combining WPMC and image analysis, as described here, provide an excellent means to efficiently evaluate and use novel genetic material in terms of whole-plant attributes.

Mary Ann L. Smith, associate professor of plant physiology

Researchers in the Department of Horticulture have used somaclonal variation to obtain thornless blackberries and red pear trees. 'Lincoln Logan', one of our thornless blackberries derived from tissue culture already has been released as a cultivar. Another thornless blackberry is at an advanced stage of testing. We also hope to find variations in fruit color in our small orchard of apple trees that were derived from tissue culture.

Because there may be an upper limit to natural variation within a cultivar, biotechnology protocols are important to supplement and direct the type of variation that we encounter. Researchers at the Department of Horticulture have worked with tomato plants that possess a gene from bacteria *(bt)* that gives resistance to certain caterpillars. Other scientists in the department have produced Solanaceous plants with good resistance to certain herbicides and are trying to introduce virus resistance to apple trees.

How much progress can be expected using biotechnology will vary with the clone, the age of the culture — older cell lines often show more somaclonal variation than newer lines — use of mutagenic agents such as radiation or chemical mutagens, and selection pressure applied to single-cell clones for stress conditions such as salt level, herbicides, microorganisms or their by-products, and specific metabolites. For instance, by placing a variable population of cells in a medium with herbicide, the cells that survive should have some resistance to the herbicide. Progress will also depend on the availability of useful genes for transfer to horticultural crops.

Robert M. Skirvin, professor of horticulture

Chimera. This pear fruit has both red and green tissues growing together. Theoretically, red trees can be produced from the red sectors and green from the green sectors.

Biotechnology in Forestry

David E. Harry, Jeffrey O. Dawson, and Robert M. Skirvin

Scientists at the Department of Forestry are conducting biotechnology research to better understand some of the diverse organisms that occupy forests, as well as to enhance methods for genetically manipulating these organisms.

Gene structure and function. Trees must often cope with environmental stress to survive. Anaerobic stress, caused by a lack of oxygen, occurs whenever demand for oxygen exceeds supply. Although a plant may experience anaerobic stress after a flood, it may also occur within metabolically active tissues of a non-flooded plant. Anaerobic stress activates a small set of genes and alters biochemical processes that generate cellular energy.

Among the genes activated by anaerobic stress, those encoding alcohol dehydrogenase (ADH) are understood the best. ADH is the enzyme that catalyzes the interconversion of acetaldehyde and ethanol. This enzyme is essential for plants to survive short-term exposures to flooding, but its physiological function is not clearly understood.

Patterns of ADH expression in woody plants are unusual when compared to nonwoody plants, probably because anaerobic stress commonly occurs within metabolically active tissues of tree stems, such as the cambium. Using classical genetic tools and recombinant DNA methods, we are studying the gene (or genes) responsible for ADH expression in different tissues of pines and cottonwoods to understand the molecular mechanisms responsible for switching these genes on and off. These studies will enable us to better understand how anaerobic stress affects tree growth and wood production.

Tissue culture and plant regeneration. Moving genes from test tubes into actual trees requires three methods: one method to shuttle genes into plant cells, one to aseptically grow plant tissues, and one to regenerate trees from isolated tissues. Our research addresses several of these areas.

One project regenerates plants from selected clones of the eastern cottonwood (*Populus deltoides*) and from immature *Populus* embryos. Because they grow so rapidly, *Populus* species are prime candidates for windbreaks and for producing wood or fiber. Four- to ten-year-old *Populus* trees can be harvested for woody biomass (to be burned directly or converted to chemical fuels) or for pulpwood.

We can dramatically alter plant development in culture by changing the type of sugar or hormones contained in growth media. We can now regenerate plants from isolated tissues of mature individuals as well as from immature embryos. Because hybrid embryos can be rescued before they abort, the latter method allows sexually incompatible *Populus* species to be crossed.

In collaboration with researchers from the Department of Plant Pathology, an-

Alder seedlings sprayed with water containing Frankia *collected from different places. Later, roots will be examined to determine the number of nitrogen-fixing nodules formed by the different* Frankia *isolates. Molecular fingerprinting may provide a means to directly identify the particular* Frankia *isolate present in the module.*

Many kinds of adaptations allow these baldcypress trees to tolerate flooding. Although their stems are above water and bathed in air, rapidly growing tissues beneath the bark may suffer a shortage of oxygen. Alcohol dehydrogenase enzymes may allow such tissues to maintain rapid growth despite shortages of oxygen.

other project transfers genes into trees and shrubs that form root nodules containing *Frankia*, a nitrogen-fixing bacterium with a diverse range of plant hosts. Initial experiments have infected plant tissues from red alder (*Alnus rubra)* and Russian olive (*Elaeagnus angustifolia*) with the bacterium *Agrobacterium rhizogenes*.

By infecting these and other plant species, *Agrobacterium* transfers a few bacterial genes into the cells of the host plants. This natural process provides a mechanism to shuttle selected genes into plants. From infected plants, we have observed morphologically and biochemically distinct shoots and roots we believe to contain transferred genes. These methods will enable genetic manipulation of nitrogen fixation, which may reduce the need for nitrogen fertilizers.

Although plants need nitrogen to grow but cannot use atmospheric nitrogen, nitrogen fixation is a process that converts atmospheric nitrogen to forms that the plants can use. Legumes such as soybeans fix nitrogen using *Rhizobium*, a different bacterium.

Microbial biology of *Frankia*. Despite the economic and environmental importance of nitrogen fixation, we know relatively little about *Frankia*. Recent technological advances allow "fingerprinting" of *Frankia* strains based on the nucleotide sequence of RNA contained in ribosomes or cellular organelles that facilitate protein synthesis. We have found that ribosomal RNA varies considerably among *Frankia* strains, so we can now characterize Frankia collected from different nodules on the same plant, from plants growing in different areas, or even from different soil samples. These methods will help to characterize the population dynamics of these poorly known nitrogen-fixing microorganisms.

David E. Harry, assistant professor of forestry; Jeffrey O. Dawson, professor of forestry; and Robert M. Skirvin, professor of horticulture

Biotechnology of Aging

Keith W. Kelley

It's exciting when scientists can apply what they learn from fundamental research on livestock to important medical problems of humans. One of the hottest developments in biotechnology of both livestock and humans is somatotropin or growth hormone, a new genetically engineered protein. As yet, growth hormone has not received approval from the Food and Drug Administration (FDA) for use in the animal food chain. However, recombinant human somatotropin, which received FDA approval in October 1985, is being used to treat about 15,000 children in the United States who were born with a deficiency of growth hormone. With treatment, these children may grow up to four inches per year. In 1989, worldwide sales of somatotropin exceeded $300 million.

Somatotropin has generated much excitement and concern about other potential clinical uses. Somatotropin may help control obesity in middle-aged humans, reverse some aspects of the aging process, improve wound healing in burn patients, augment the physical abilities of athletes, and both improve growth rate and reduce carcass fat in domestic food or animals.

The *New England Journal of Medicine* reported in 1990 that giving somatotropin to men between 61 and 81 years of age increased lean body mass and reduced body fat. Unfortunately, the long-term effects on human or animal health are not yet known, but somatotropin is known to affect several activities of cells of the immune system.

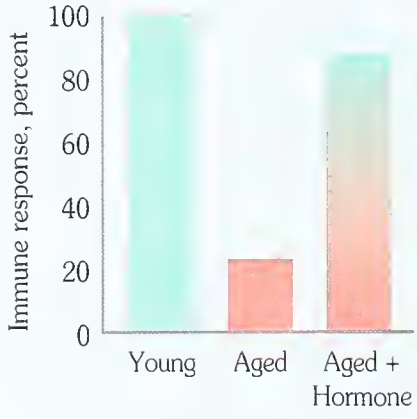
Aging's Effects on the Human Immune System

Rapid growth of the aging population and the enormous accompanying costs of health care make research about aging everyone's concern. In the United States, nearly 30 million people are over age 65, and this number will double within the next 30 years.

By the year 2000, 5 million Americans will be over age 85. Nearly 40 percent of those over 85 require daily assistance from relatives or professional caregivers to maintain normal, daily activities.

As a group, the elderly have an increased incidence of respiratory, neoplastic, arthritic, and cardiovascular diseases, and a higher incidence of mortality from bacterial infections due to gram-negative sepsis. Among the aged, influenza and pneumonia are the fourth leading cause of death; tuberculosis occurs most often and leads to the highest death rate among the elderly. Infectious endocarditis causes over 50 percent of deaths when it occurs in people over age 60. Fifteen percent of the aged population suffer from urinary tract infections. The elderly also have an impaired ability to develop fevers following infection. It is generally believed that the increase in disease prevalence is related to aberrations that occur in regulation of the immune systems of the aged.

Somatotropin-secreting pituitary cells significantly improve the immune response of aged rats.



Source: Kelley et al., 1986, *Proceedings of the National Academy of Science USA*, 83:5663.

Somatotropin, Aging, and the Immune System

Five years ago, immunologists, muscle biologists, and veterinarians working within the College of Agriculture discovered an important link in aged animals between the immune system and somatotropin. For years it has been known that the size of the thymus gland in both humans and animals decreases with age. It is also now recognized that human somatotropin secretion declines as we age. Maximal size of the thymus gland coincides with maximal secretion of somatotropin at puberty; by age 60, only fatty remnants of the thymus gland remain.

This process was thought to be irreversible. We postulated that giving somatotropin in the form of hormone-secreting pituitary cells might permit the thymus gland to grow again in aged animals. We also tested the possibility that this regenerated thymus gland might aug-

ment certain aspects of the immune response that deteriorate during aging.

Results from these experiments were amazing. As expected, we could detect only remnants of the thymus gland in control rats equivalent to 54 year-old humans. But aged rats that had been implanted with hormone-secreting pituitary cells were able to regenerate their thymus glands to the point of being indistinguishable from those of young rats. Furthermore, the immune response which normally declines with age (as assessed by the growth of T lymphocytes) was significantly improved (see figure). T lymphocytes, cells that are derived from the thymus gland, are required for most immune responses.

We have now shown that the real cellular target for the action of somatotropin may be the macrophage, a type of phagocytic cell in the immune system that eats bacteria and kills tumor cells with toxic chemicals. Because secretion of growth hormone declines in older humans and animals, these data suggest that genetically engineered somatotropin may be useful in delaying or preventing the age-related change in various immune functions. Experiments are evaluating these possibilities, but research on aging is quite expensive. For example, scientists pay as much as $150 for a two-year-old rat — rats can live up to three years under excellent management conditions. The enormous costs of conducting aging research, which requires between 50 and 100 rats per study, limit the number of experiments that can be run.

Somatotropin and the Immune System of Livestock

The experiments with aged rats provided the impetus to study whether somatotropin affects the immune system of farm animals. Initial experiments concentrated on pigs' phagocytic cells, such as macrophages and neutrophils, which are critically important for destroying many types of bacterial and fungal pathogens. Using genetically engineered porcine somatotropin that has already been proven to increase growth rate and reduce carcass fat, we showed that this protein increases the capability of macrophages to produce a free radical known as superoxide anion. This molecule plays an important role in the killing of bacteria by porcine phagocytic cells. We have now shown in humans (University of Illinois faculty and graduate students) and in pigs and cattle that recombinant somatotropin increases the secretion of superoxide anion by another type of phagocytic cell, the polymorphonuclear neutrophil. In pigs, these somatotropin-treated neutrophils are also more efficient in killing *Escherichia coli* in vitro.

All the experiments described above were conducted by adding recombinant porcine somatotropin to phagocytic cells in a test tube, so it is not known if similar results will be obtained if this genetically engineered version of somatotropin is administered directly to pigs. New data from scientists at the University of Guelph in Canada, however, show that injecting recombinant bovine somatotropin into lactating dairy cows increases a number of immune responses.

Summary

New techniques in molecular biology can potentially revolutionize animal agriculture. Somatotropin is the first genetically engineered protein that has been extensively tested and shown to increase a number of economically important traits in dairy cattle, pigs, and sheep. Research conducted at the University of Illinois has shown that this same molecule might also be one of the important keys to understanding why we age and how to augment the immune response of both humans and livestock.

Keith W. Kelley, professor of immunophysiology, Department of Animal Sciences

In Progress

New Biosynthetic Pathway

The discovery of new metabolic intermediates brings scientists one step closer to figuring out how plants make chlorophyll b, a pigment important for photosynthesis and plant production.

University of Illinois plant physiologist Constantin Rebeiz, postdoctoral fellow Vinay Shedbalkar, and graduate student Ioannis Ioannides have discovered new tetrapyrroles which appear to be intermediates in chlorophyll b formation.

"This is like finding a key that will allow the whole process to unfold. Now, we can investigate the biochemistry of the various reactions responsible for chlorophyll b formation in nature," Rebeiz said. "The implications are fundamental at this stage; it is a discovery that others will build upon."

Scientists identified chlorophyll b in the 1940s. Although they have developed hypotheses to explain how plants produce the pigment, the process remains a mystery. About eight years ago, Rebeiz, Shedbalkar, and Ioannides became intrigued enough to begin working on the problem at the U of I Laboratory of Plant Pigment Biochemistry and Photobiology.

Rebeiz said the chlorophyll b biosynthetic pathway appears to be highly complex and may take several years to research. Papers on the progress of this ongoing research are being prepared for journal publication.

Researcher Honored for Contribution to Agriculture

Research aimed at boosting the capacity of a crop plant to make its own food for growth and development earned University of Illinois plant physiologist William Ogren the 1990 Alexander von Humboldt Foundation Award. Each year, a U.S. scientist who has made the most significant contribution to agriculture in America over the past five years is selected for the award, which carries a $10,000 stipend.

The award recognized the recent progress Ogren's research team has made in the laboratory. With a goal of changing plant genes to make photosynthesis more efficient, they have identified key enzymes, genes, and proteins and developed techniques for isolating, cloning, and modifying these genes. Future work will focus on transferring altered genes.

Ogren holds joint appointments in the U of I Agronomy and Plant Biology departments and is research leader of the U.S. Department of Agriculture's Agricultural Research Service Photosynthesis Research Unit.

Destruction of Cancer Cells

For innovative research, two disciplines may be better than one. Building upon their own independent research in cell metabolism, University of Illinois plant physiologist Constantin A. Rebeiz, animal scientist Keith Kelley, and animal sciences graduate student Natalie Rebeiz, have combined skills to develop a treatment that causes cells to destroy themselves.

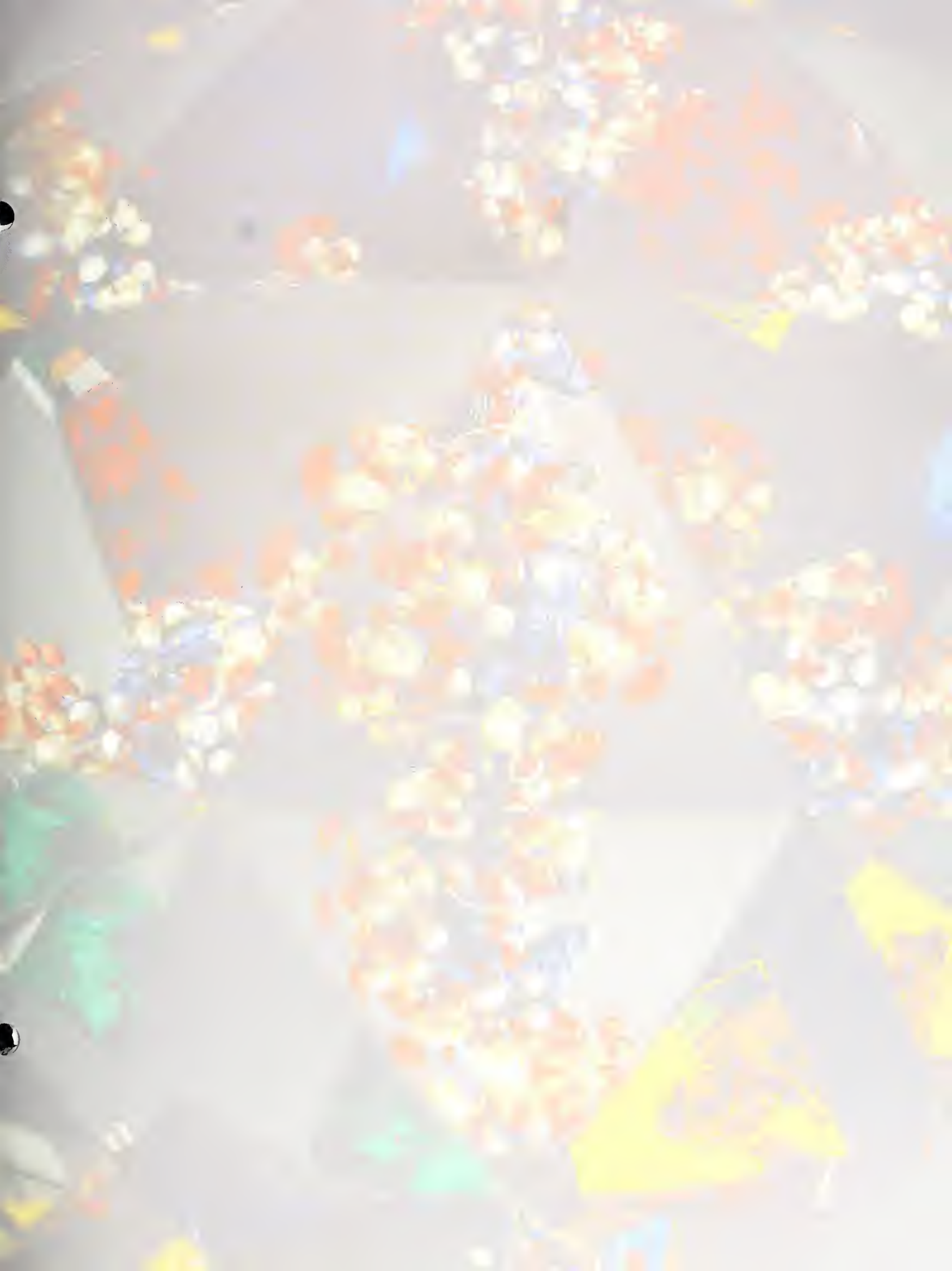
They are using drugs and light to induce cancer cells to self-destruct. If successful, the experimental process could replace surgery now used to treat some tumors.

Although it is a novel conceptual approach to tumor treatment, manipulating cell metabolism is not new in cell biology, according to Kelley.

"We know how to kill a cell in many different ways. But, rather than injecting a chemical that kills cells, we have developed ways of modulating, destructively, cell metabolism," he said. "It opens a variety of choices and alternatives not presently available for phototherapy of cancer cells."

So far, the team has focused on interfering with metabolism of rapidly multiplying cancer cells in laboratory cultures. The next step will be to develop a model for testing the new approach on solid tumors.

"We know it works in the test tube. Now, we need to move to solid breast tumors, and if we are lucky, we may be able to inject a tumor with a solution of chemicals and a few hours later, treat it with a laser beam — no surgery — and achieve destruction of some tumor cells," Rebeiz said.



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